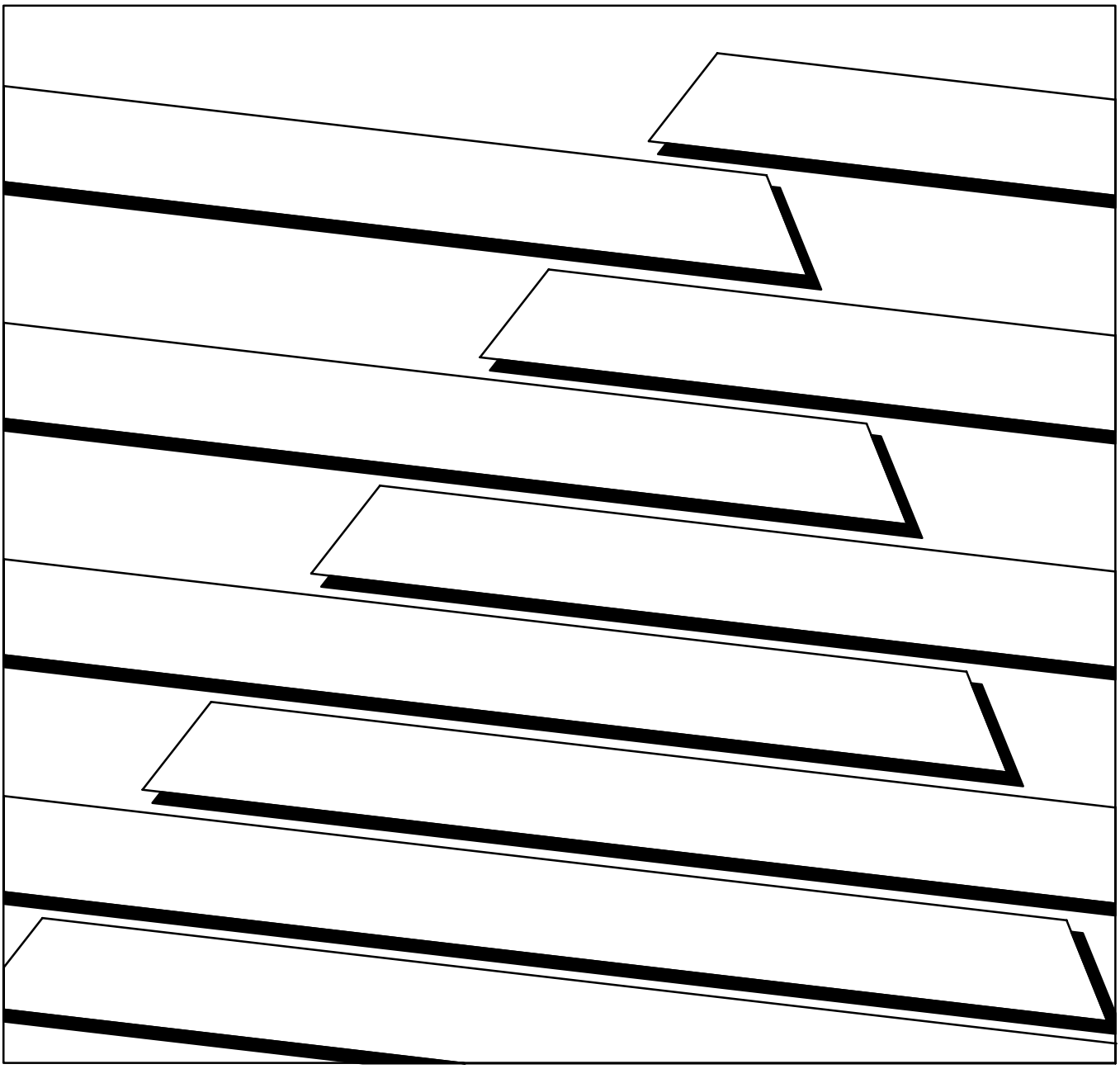
ALLEN-BRADLEY

IBM PC I/O Scanner

(Cat. No. 6008-SI)

User Manual



Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, “Safety Guidelines For The Application, Installation and Maintenance of Solid State Control” (available from your local Allen-Bradley office) describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

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Throughout this manual we make notes to alert you to possible injury to people or damage to equipment under specific circumstances.

WARNING: Tells readers where people may be hurt if procedures are not followed properly.

CAUTION: Tells readers where machinery may be damaged or economic loss can occur if procedures are not followed properly.

Warnings and Cautions:

- identify a possible trouble spot
- tell what causes the trouble
- give the result of improper action
- tell the reader how to avoid trouble

Important: We recommend that you frequently back up your application programs on an appropriate storage medium to avoid possible data loss.

Summary of Changes

Changes to Software

Use this document with revision 1.2 of the host software package for the IBM PC I/O Scanner. The host software has been updated to use Microsoft and Borland compilers.

The new information is marked with a vertical black bar in the margin.

You'll find this new information:	On page:
Contents of host software package	4-1
Borland compiler	
installing	4-3
compiling and linking	4-12
using the /d option	4-11
Microsoft compiler	
installing	4-5
compiling and linking	4-14

Table of Contents

Important User Information I

Summary of Changes i

Changes to Software i

Using This Manual 1-1

Manual's Objectives 1-1
Audience 1-1
Related Publications 1-1
Required Hardware 1-1
Required Software 1-2
Source Code 1-2
Conventions 1-2

I/O Scanner Concepts 2-1

Chapter Objectives 2-1
How Does the Scanner Relate to 1771–I/O 2-1
Terms 2-3
I/O Addressing 2-5
What the Scanner Does 2-6
Operating Modes 2-7
Global RAM 2-7
Data Paths 2-8
Scanner Commands 2-9
Host Watchdog 2-10
Scanner Watchdog 2-10

Installation 3-1

Chapter Objectives 3-1
Using the Scanner with Other Products 3-1
Installation Procedure 3-5

Programming Overview 4-1

Chapter Objectives 4-1
Disk Inventory 4-1
Installing the Borland Version 4-3
Installing the Microsoft Version 4-5
Writing Your Program 4-7
Compiling and Linking the Borland C++ 2.0 Version 4-12
Compiling and Linking the Borland Turbo C++ 1.0 Version 4-13

Compiling and Linking the Microsoft C 5.1 or 6.0 Version 4-14
Further Information 4-15

Startup, Status, and Shutdown 5-1

Chapter Objectives 5-1
Overview 5-1
Startup 5-2
Host Watchdog 5-6
Scanner Status 5-7
Shutdown 5-12

Discrete I/O 6-1

Chapter Objectives 6-1
Direct Image Table Access 6-1
Library Routines 6-4
Print or Display Image Table 6-9
Timing of Discrete I/O 6-10

Scanner Management 7-1

Chapter Objectives 7-1
Overview 7-1
Data Structure (Packet) 7-2
Executing a Management Request 7-3
Autoconfigure and Link Status Information 7-15
Configuration Information Byte 7-16
Fault and Fault Dependent Group Information Byte 7-17
Confirmation Status Codes 7-19
Print or Display Results 7-20

Block Transfer 8-1

Chapter Objectives 8-1
Overview 8-1
QBT Data Structure (Packet) 8-2
Queueing a Block Transfer 8-4
Time to Completion 8-6
Polling for Completion 8-8
Confirmation Status Codes 8-11
Print or Display Results 8-12
Unsolicited Block Transfer 8-13
Block Transfer to PLC5's in Adapter Mode 8-13
Block Transfer to a 1771–DCM 8-17

General Support Features 9-1

Chapter Objectives 9-1
Timing Loops 9-1
Date and Time Stamp 9-3
Command Translation 9-5

User Diagnostic Program 10-1

Chapter Objectives 10-1
Starting the Program 10-2
Program Operation 10-3

Troubleshooting 11-1

Chapter Objectives 11-1
Troubleshooting the I/O Scanner 11-1

Header Definitions A-1

Chapter 1

Using This Manual

Manual's Objectives

This manual describes the operation and use of the IBM PC I/O Scanner (cat. no. 6008-SI) with the supplied host software driver. After reading this manual, you should be able to:

- install the scanner board in your computer
- write a program that runs on your computer to control the scanner for your application
- diagnose and correct most of the problems that might occur.

This manual begins with an introduction to I/O scanner concepts and proceeds to detailed instructions on how to install and program your scanner.

Audience

We assume that you have experience in system development and integration and in writing software for the IBM Personal Computer family or compatibles. We also assume that you have a working knowledge of the C programming language, including the concepts of structures and pointers. Prior knowledge of Allen- Bradley 1771 Series I/O products is helpful but not essential.

Related Publications

Use this manual with its companion manual, the I/O Concepts Manual. Refer to the manuals that accompany the 1771 Series I/O modules and hardware you intend to use with your system.

Required Hardware

You need a computer from the IBM Personal Computer series, such as the PC/AT or PC/XT, or a compatible such as the Allen-Bradley Industrial Terminal T50, T60, and T35. The scanner board is installed inside the computer.

The choice of 1771 Series I/O modules depends on your application.

A printer attached to your computer may be helpful but is not required.

Required Software

You need the MS–DOS operating system, version 3.0 or higher. If you're using the Microsoft C version of the scanner driver software, you'll need a Microsoft C compiler, version 5.1 or higher (version 6.0 recommended). If you're using the Borland C version of our software, you'll need a Borland C compiler, Turbo C++ 1.0 or higher (Borland C++ 2.0 recommended).

Source Code

Source code for library routines and the interrupt handler is available for a nominal charge. To obtain source code, you must contact Order Services and request 6008-SIDC software. They will ship you a license agreement. Return the signed agreement. A-B source code will be supplied on 3.5-inch and 5.25-inch diskettes.

Conventions

In this manual, **this type** is used for special names, such as names of files and C language identifiers.

The hexidecimal equivalent of selected error codes and commands are given in the header definition files found in appendix A at the back of this manual.

Numbers in this document are in decimal unless otherwise noted. Binary numbers are marked with a trailing (binary), and hexadecimal numbers with a trailing (hex); for example, 11010(binary) = 26 = 1A(hex).

Bits are numbered so that bit 0 is the low-order bit. For example, bit 4 is four bits left of bit 0 and has a value of 2^4=16. Following C conventions, array subscripts start at 0.

Chapter 2

I/O Scanner Concepts

Chapter Objectives

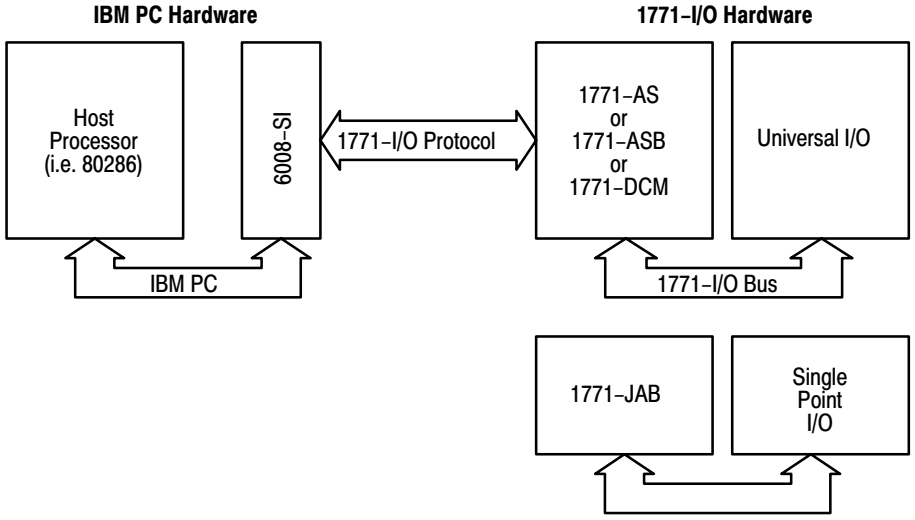
This chapter explains basic concepts and provides an overview of the operation of the IBM PC I/O Scanner. After reading this chapter you should understand:

- how we use certain words with special meanings in this manual
- how information moves between your program and the outside world
- how your program can issue commands to affect operation of the scanner
- how the safety features, called watchdogs, work

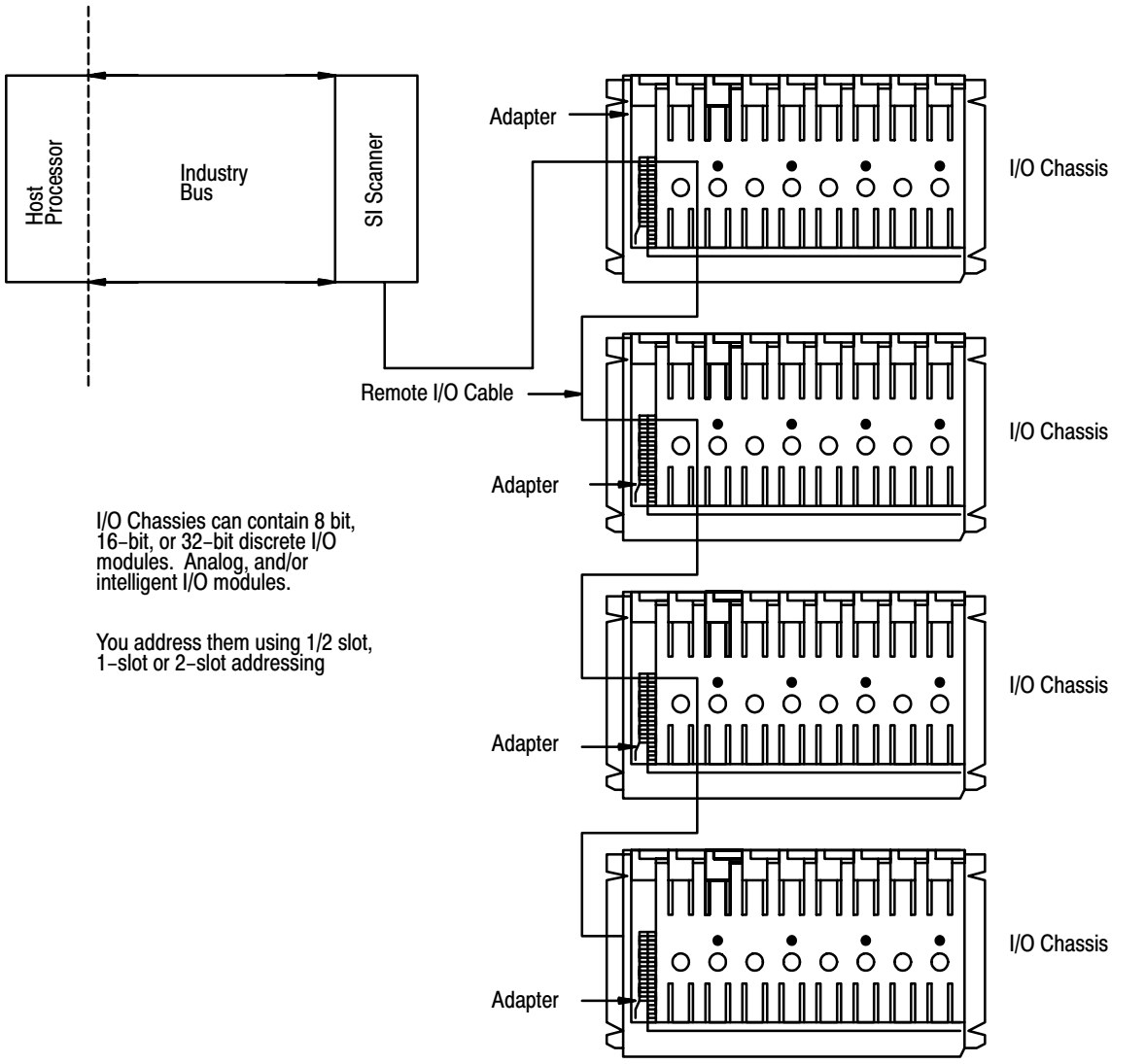
How Does the Scanner Relate to 1771–I/O

The scanner uses the 1771 Remote I/O protocol to communicate with Allen–Bradley I/O modules. You don't have to know the specifics of the protocol to use the scanner with the I/O modules, but you do need to know a few terms.

The scanner is an Allen–Bradley card that you install in the host computer (or host). Typical hosts are the IBM PC/AT class (including the Allen–Bradley T50, T60, and T35 Industrial Terminals and 6121 Industrial Computer) and the IBM PC/XT class of machines (including the Allen–Bradley 6120 Industrial Computer).



I/O modules sit in one or more chassis. An I/O chassis is a housing that holds one adapter and 1, 2, 4, 8, 12, or 16 I/O modules. The adapter is the communication interface between the scanner and the chassis. The scanner communicates with the adapter through shielded two–conductor twisted–pair cable (the “blue hose”). In turn, the adapter monitors and controls the I/O modules through the backplane of the chassis. You can connect up to 16 chassis to the scanner on the blue hose. You can combine chassis in any way that results in 8 or less rack addresses.



We can divide I/O, and therefore I/O modules, into discrete and intelligent modules.

Discrete I/O is characterized by one terminal (or point) per I/O image table bit. Your program handles discrete I/O through I/O image tables, where each input or output terminal corresponds to one of the 1024 input and 1024 output image table bits (64 x 16 bits = 1024 bits.)

The input image table is an area of memory that monitors the terminals of discrete input modules. When an input switch is closed, the corresponding bit is set (1). The output image table is an area of memory that controls output terminals of output modules. After a bit is set to 1, the corresponding switch is closed or the terminal is energized.

A standard–density module is a discrete input or output module that has 4, 6, or typically 8 input or output terminals. A high–density module is a discrete input or output module that has 16 input or output terminals. A quad–density module is a discrete input or output module that has 32 input or output terminals.

Intelligent I/O is characterized by the transmission of one or more 16–bit words in a particular format to or from an I/O module. A block transfer (BT) is the transmission of data to or from an intelligent I/O module. A BT read or read BT transfers information (typically analog input and status data) from the module to the host; a BT write or write BT transfers data (typically analog output and configuration data) from the host to the module.

Terms

You should become familiar with these terms used to describe the I/O subsystem.

Input image table: An area of memory that monitors input terminals of input modules. When an input switch is closed, its corresponding input bit is set. 64 16–bit words (1024 points) are available.

Output image table: An area of memory that controls output switches of output modules. When a bit is set, its corresponding output is energized. 64 16–bit words (1024 points) are available.

Discrete I/O: I/O characterized by one terminal per image table bit (terminal and point are the same).

Standard density module: Discrete I/O module having four, six, or typically eight input or output points.

High density module: Discrete I/O module having 16 input or output points.

Quad density module: Discrete I/O module having 32 input or output points.

I/O chassis: One of four different housings sized to hold either four, eight, twelve, or sixteen discrete I/O modules.

Slot: Position in an I/O chassis the width of one discrete I/O module.

I/O group: An addressing concept representing 16 input bits (one input image table word) and 16 output bits (one output image table word).

In hardware, an I/O group can represent one or two slots in an I/O chassis. It has an address number.

Half–slot addressing: Addressing where an I/O group represents a half of a slot.

One–slot addressing: Addressing where an I/O group represents one slot.

Two–slot addressing: Addressing where an I/O group represents two slots.

I/O rack number: An addressing concept representing 8 I/O groups. An I/O rack number can be distributed over one, two, three, or four I/O chassis; or two rack numbers can be assigned to one I/O chassis, depending on chassis size and your application requirements.

Module address: An address that defines the physical location of the module in the I/O chassis by its I/O rack number and starting slot number.

I/O update: The scanner's serial scan of all I/O chassis in the I/O subsystem. This scan is asynchronous to scans between the scanner and host processor.

Scan list: A list specifying the order in which I/O adapters are to be scanned. It is specified by the host and sent to the scanner module as a scanner management command. Although a maximum of 16 I/O adapters is allowed, the scan list can specify a maximum of 64 I/O adapters. This is done to allow the scanner to scan adapters more than once during its scan cycle if more frequent updates are desired.

Block transfer: The transfer of data to or from an intelligent I/O module up to 64 words at a time.

Scanner management request: A command from the host to the scanner used to control and configure the scanner board.

Fault dependent group: A group of I/O adapters treated as a single entity for the purposes of fault detection. If one of the defined group faults all in the group are in fault.

I/O Addressing

You assign each adapter an I/O rack number (0 to 7) by setting switches on the adapter. A rack may be single chassis; or two to four chassis may be comprised in one rack number; or a single chassis can be addressed as two racks. It is not necessary to assign rack numbers sequentially: for instance, you could have a full rack 0, half a rack in rack 3, and a quarter rack in groups 6–7 of rack 7.

For addressing purposes, each rack is equivalent to a block of 8 I/O groups in the I/O image table. Groups within a rack are numbered from 0 to 7. An I/O group is two 16–bit words, one from the output image table and one from the input image table, with the same address. (Please refer to the I/O Concepts Manual for more information.) In most applications, only the input word or only the output word is used in any given I/O group.

Here is an example layout of the output image table:

word # (hex)	rack	Group							
		0	1	2	3	4	5	6	7
00–07	0	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
08–0F	1	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
10–17	2	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
18–1F	3	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
20–27	4	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
28–2F	5	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
30–37	6	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
38–3F	7	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

The word numbers above can be used as subscripts. (We'll look closely at that in chapter 6, Discrete I/O.) Each 16–bit word corresponds to 16 discrete I/O terminal positions, terminal 17 octal (15 decimal) to the high–order bit and terminal 00 to the low–order bit.

Just as each I/O group has an address, so does each adapter. Adapter addresses are used in the scan list (see, What the Scanner Does, below). The adapter address is the address of the first I/O group covered by the adapter, divided by 2. This is numerically the same as (rack x 4) + (starting group / 2), where the rack and group are both numbered from 0 to 7 as shown above. If you prefer, you can think of 1/4 racks being numbered from 0 to 3, and then the adapter address is (rack x 4) + (quarter).

A slot is a position in an I/O chassis for one I/O module. In one–slot or single–slot addressing, an I/O group represents a single slot. In two–slot or double–slot addressing, an I/O group represents two slots.

What the Scanner Does

The scanner runs asynchronously in relation to the host. When either one wants to get the other's attention, it must issue a hardware interrupt. Information is passed through a global RAM. Both the host and the scanner have the ability to postpone servicing an interrupt if in the middle of another interrupt–driven task.

The scanner maintains a scan list, which is a list of adapters to be serviced by the scanner. A given adapter may appear once, several times, or not at all in the scan list. (The scan list is empty until you perform AUTOCONFIGURE at which point AUTOCONFIGURE puts every adapter in the list once.) The scan list starts as simply the list of adapters, each occurring once, but your program can issue a scanner command to alter the scan list.)

An exchange (or an adapter scan) is the scanner's interchange of information with one adapter. During an exchange, the scanner may receive data or status information from the adapter or send data or commands to the adapter, or both. Both block transfers and discrete I/O transfers can be done during the same exchange if the adapter's chassis contains both kinds of I/O modules.

After servicing each adapter, the scanner looks at its command queue to see if any commands are waiting. If so, and if the current operating mode allows, the scanner executes one command. If the scanner has a confirmation of this command or of a previously executed command, it puts the confirmation in the global RAM and interrupts the host.

The scan list is circular: each time the scanner reaches the end of the scan list it starts again at the beginning. An I/O scan (sometimes called just a scan) is one complete cycle by the scanner through the scan list, from any point to the same point.

Every time the host interrupts the scanner, the scanner puts a marker in the scan list at the point of the adapter most recently scanned. If the scanner works its way through the scan list to the same point without receiving an interrupt from the host, the scanner interrupts the host. (If the scan list contains no adapters, the scanner waits for 5 ms before interrupting the host.)

Thus you can be certain that the I/O image tables are refreshed once per scan list. Partial refreshes take place more frequently if your program executes a lot of block transfers or management requests: whenever the global ram is transferred the I/O image tables are refreshed as far as the scanner has got in the scan list since the last interrupt. Your program can also force a partial refresh: see the **update** function in chapter 6, Discrete I/O.

Operating Modes

The scanner has three modes of operation: program, test, and run modes. Discrete inputs are read in all three modes.

- In program mode no discrete outputs are sent to the adapters, and the adapters are instructed to hold all discrete outputs reset (zero). The scanner holds any block transfer requests in its queue without servicing them.
- In test mode the adapters are still instructed to hold discrete outputs reset, but the scanner sends discrete information to them. Block transfers can proceed in test mode, but their outputs will be held reset.
- In run mode discrete output information is sent to the adapters, and the adapters are permitted to update the output modules. Block transfers may be performed.

When your program first starts up scanner operation, the scanner is in program mode. Your program must issue a command to change to run mode.

Global RAM

The scanner has a 2048–byte area of RAM that we call a global RAM, shared by both the IBM PC and the scanner. This is not a true global RAM, because the host and the scanner can't access it at the same time. Instead, the host and the scanner exchange control of the global RAM by means of interrupts. When the scanner interrupts the host, the scanner is turning over control of the global RAM to the host. When the host interrupts the scanner, either the host has the global RAM and wants to return it or the host doesn't have the global RAM but wants access to it.

Access to the global RAM is ultimately controlled by hardware and by scanner firmware. For the host side, we supply an interrupt handler or interrupt service routine that is automatically invoked whenever the scanner interrupts the host. Our interrupt service routine copies information as needed between your program's data area and the global RAM.

Because our interrupt handler takes care of all details of the global RAM, you don't have to be concerned with the bits and bytes. You should know that the global RAM contains two kinds of information:

- the I/O image tables are comprised of an output image image table and an input image table. Every time control of the global RAM is transferred, the interrupt routine copies new inputs to your program's data area from the global RAM and new outputs from your program's data area to the global RAM.
- a mailbox area is where the host can send commands to the scanner and the scanner sends back confirmations and data. A list of commands is given later in this chapter.

Data Paths

Here is the path followed by a discrete input bit:

- An external device causes an input of a discrete input module to turn "on."
- When next asked by the adapter, the input module reports the new input information. The adapter updates its internal input image table by setting the bit corresponding to the particular input point.
- When next scanned by the scanner, the adapter reports the new input information. The scanner updates the input image table in the global RAM by setting the bit corresponding to the particular input point.
- The host interrupt handler reads the input image information in the global RAM and copies it to a duplicate input image table available to your program. Your program now knows that an input on a particular input module is "on."

The path of an output bit is essentially the reverse of the input path:

- Your program sets a bit in its output image table. Your program knows that this bit maps to an output on a particular output module.
- The scanner interrupts the host, the interrupt handler copies your program's output image for that rack to the global RAM.
- When the scanner next scans the adapter controlling the particular output module, it tells the adapter to update its output image table with the new information.
- The adapter tells the discrete output module to update its outputs with the new information.

- The discrete output module turns on the output. Any external device attached to the output module then activates.

For timing information, please see Timing of Discrete I/O in chapter 6, Discrete I/O.

Scanner Commands

There are two types of scanner commands, block transfers and management requests. There are two block transfer commands (BT commands):

- block transfer read
- block transfer write

A management request affects the operation of the scanner itself. There are six management requests:

- **set mode** changes the scanner's operating mode to program, test, or run mode
- **autoconfigure** goes on the link to see what devices are attached
- **scan list** changes the order in which adapters are scanned, and their relative frequency
- **link status** asks the scanner to report all information it has about the adapters that are connected
- **setup** changes the baud rate and connects or disconnects the line termination resistor
- **fault dependent group** designates one or more groups of adapters such that, if one adapter in a group is faulted, the scanner instructs the others to be faulted also

The control/status and general data areas are used to transfer scanner management commands to the scanner and provide status information to the host. In addition, this area of the global RAM is used for block transfers between the host and intelligent I/O devices in the I/O system.

Host Watchdog

Suppose that your program crashes, either because of logic errors or because of operator intervention. Or suppose that through logic errors your program gets into an infinite loop. In these cases the program is no longer sending meaningful information to the scanner through the interrupt handler. There is no way for the interrupt service routine (ISR) to recognize all possible host program failures reliably, so instead a “host watchdog’’ scheme has been implemented.

In essence, your program must take a particular action every so often (by default, every second). If the ISR recognizes that the required action has not been taken recently enough, the ISR infers that your program has failed and simply stops talking to the scanner. The scanner in turn recognizes this as a host failure and goes off the link within 50 ms; all the adapters go inactive and output terminals go to last state or reset as determined by switches you set on the chassis.

We’ll tell you about the necessary programming steps in chapter 5, Startup, Status, and Shutdown.

Scanner Watchdog

If the host computer doesn’t respond to an interrupt from the scanner within 100 ms or less, the scanner assumes that the host hardware and BIOS is no longer active. In this case the scanner goes off the link, and 50 ms later the adapters set the output modules in last state or reset according to your switch settings. The scanner then goes into its power–up sequence, waiting for new startup commands from the host.

This scanner watchdog feature lets you end one program run and start another without cycling host power. Even if your program locks up the host computer, if you are able to do a soft reset (`Ctrl-Alt-Del`) the scanner is ready and waiting for your program. More importantly, if your program fails or is interrupted, even by a reboot of the computer, all discrete outputs are in last state or reset, according to the switches you set on the adapters.

Chapter 3

Installation

Chapter Objectives

This chapter explains how to install the IBM PC I/O Scanner. After reading this chapter you should be able to:

- determine whether you already have hardware or software products installed that would conflict with the scanner
- configure the scanner board for a suitable address in your host's RAM
- install the scanner board in the host
- connect the 1771 Series I/O cable to the scanner.

In this manual, we do not explain how to cable and configure 1771 Series I/O products. For that information, please refer to the manuals that came with those products.

Using the Scanner with Other Products

You need to be aware of possible hardware or software conflicts between other products and the scanner. In this section we point out the hardware and software features in the scanner that might lead to conflict with other products, and where possible we tell you how to avoid those conflicts. However, there are so many add-ons available that we cannot guarantee that the scanner works with any particular one.

Hardware Interrupt

On the system board, the scanner can use interrupt request lines IRQ3, IRQ5, IRQ10, and IRQ12. These interrupt request lines are selected by positioning the jumper located on the scanner board. Results are unpredictable if any other devices use these lines. In particular, you can't have two IBM I/O scanners operating in the same host, since the host software cannot direct Allen-Bradley I/O calls to a particular scanner board.

Allen-Bradley products that use the IRQ3 include the 1784-KTP and the 6121-CBB 'combo' card (used with the 6120 and 6121 Industrial Computers).

IBM's Technical Reference Manuals show line IRQ3 used by the secondary serial port (COM2 device). If you have 2 serial ports active on your host computer and you have selected IRQ3, you must disable COM2 before installing the scanner board. (Many multi-junction cards have jumpers to disable this port; see your manufacturer's documentation for details.)

CAUTION: If you have other cards that use the interrupt line you have selected, (IRQ3, IRQ5, IRQ10, or IRQ12), physically disconnect them to avoid damaging the 6008-SI or other cards.

To change the interrupt request line setting, complete these steps:

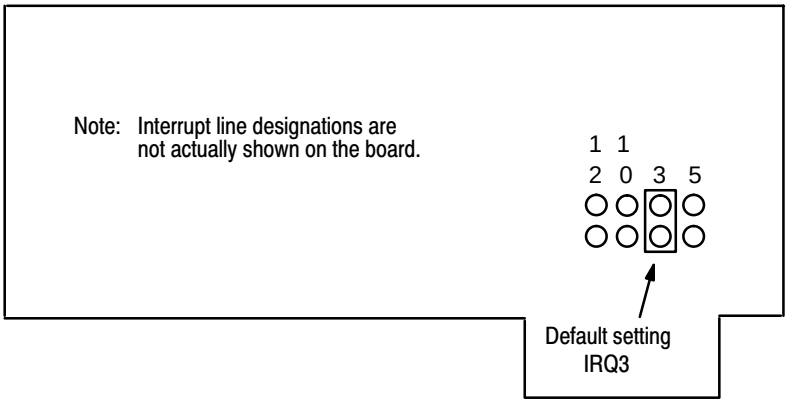
1. Remove the cover from the computer that contains the I/O scanner.

2. Remove the I/O scanner from the computer.

3. Remove the four screws securing the daughterboard to the main board. Unplug and remove the daughterboard.

4. Locate the double row of stake pins on the main board (see Figure 3.1). A jumper plug connects 2 pins to select the interrupt request line.

Figure 3.1
Location of Interrupt Request Line Jumper Plug



5. To change the setting, pull the jumper off the pins and reposition it on the pins for the interrupt line you desire. See Table 3.A for interrupt request line definitions.

Table 3.A
Interrupt Request Line Definitions

Interrupt Line:	Explanation:
IRQ3	Default setting. Conflicts with COM2 port on machines so equipped. Conflicts with the KTP card.
IRQ5	This setting conflicts with the hard disk controller when the card is used in an IBM-XT or -AT clone. This setting would also conflict with the LPT2 port on machine so equipped.
IRQ10	Not available on IBM-XT. Not assigned on 1784-T50 or IBM-AT, but may conflict with 3rd party boards.
IRQ12	Not available on IBM-XT. Not assigned on 1784-T50 or IBM-AT, but may conflict with 3rd party boards.

6. Write your application software to use the newly selected interrupt request line setting.

Software Interrupt

The host receives interrupts from the scanner through the selected line (IRQ3, IRQ5, IRQ10, or IRQ12). Table 3.B lists the software interrupt vectors.

Table 3.B
Software Interrupt Vectors

Interrupt Line:	Software Interrupt Vector:
IRQ3	0Bh
IRQ5	0Dh
IRQ10	072h
IRQ12	074h

Results are unpredictable if you have any other hardware that uses interrupt IRQ3, IRQ5, IRQ10, or IRQ12 (It is likely that the other software simply ceases functioning while your scanner 0 interface program is running, but we cannot guarantee that this is the only result).

The scanner driver routines also use the timer follow–on interrupt, number 1Ch. After its own processing, the scanner code will call any previously set follow–ons to interrupt 1Ch. If the other software is taking too great a portion of system resources, your scanner application program may not operate correctly.

Despite IBM recommendations to the contrary, some resident software uses the system timer hardware interrupt, number 8, rather than the follow-on described in the preceding paragraph. The scanner may work erratically or may fail to work at all if such programs are active when a scanner program is started.

I/O Ports

The scanner does not use any I/O ports.

RAM Address

DIP switches on the scanner board let you configure it to any starting address in RAM, from 0400(hex) to FC00(hex), in increments of 4000(hex) = 16 K bytes. (The scanner cannot be configured to operate in extended or expanded memory.) The scanner board occupies 1801(hex) (6K+1) bytes beginning at the address you select. You are responsible for selecting an address that starts at a free 6K+1 byte range.

The documentation for each of your add-on boards should tell you which addresses (if any) it uses in system RAM. In addition, we can tell you about the following common memory uses:

- monochrome display memory: B000(hex)-B7FF(hex)
- color/graphics display memory: B800(hex)-BFFF(hex)
- Enhanced Graphics Adapter memory: C000(hex)-C3FF(hex) for the BIOS, plus an area that could be as large as A000(hex)-BFFF(hex), depending on the display mode
- hard disk BIOS (on the PC XT, not the PC AT):
- C800(hex)-CBFF(hex) for the first controller, CC00(hex)-CFFF(hex) for the second controller if a second one is installed
- cartridge ROM reserved area: E000(hex)-EFFF(hex) on some systems
- ROM BIOS: F000(hex)-FFFF(hex)

Use the above information, and documentation from the manufacturers of your add-on boards, to select an area of memory that is available for the scanner. During the installation process you'll set switches according to the memory area you select.

Installation Procedure

The procedure of installing the scanner board in the host has three main steps:

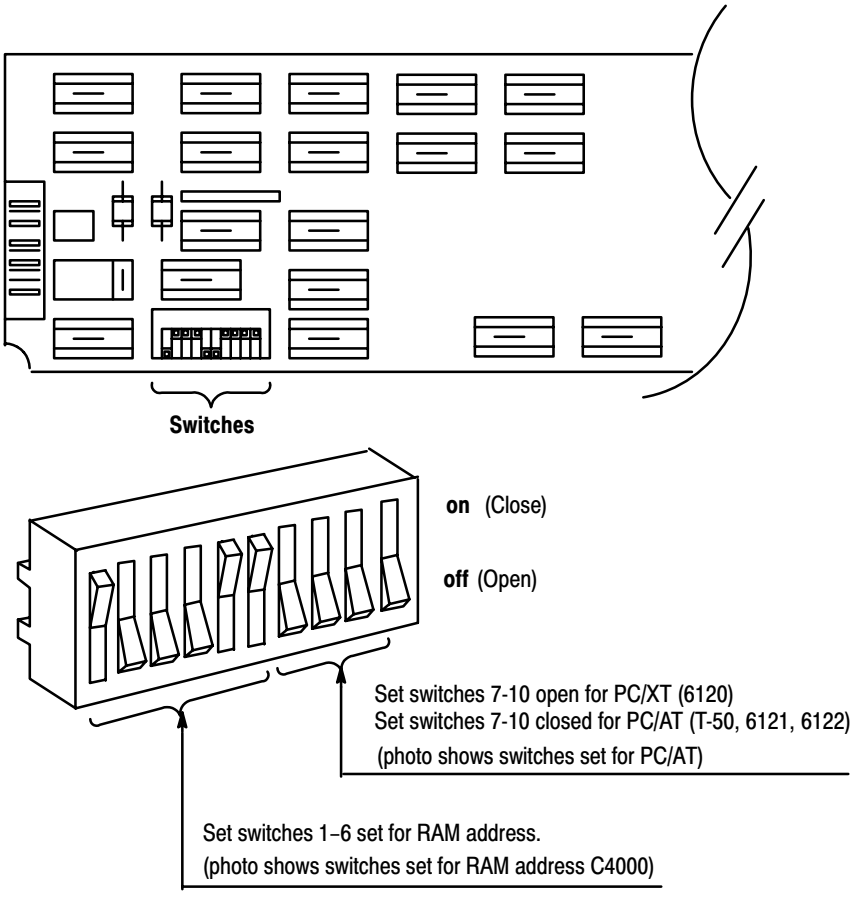
1. Set the scanner board switch block for the memory address you selected earlier.
2. Plug the scanner into a slot in the host computer.
3. Connect the I/O cable to the scanner.

In this section we'll look at those steps in detail.

Switch Settings

The scanner board has one block of ten DIP switches to be set at installation time.

Figure 3.2
Dip Switch Location on Scanner Board


Switches
on (Close)
off (Open)
Set switches 7-10 open for PC/XT (6120)
Set switches 7-10 closed for PC/AT (T-50, 6121, 6122)
(photo shows switches set for PC/AT)
Set switches 1–6 set for RAM address.
(photo shows switches set for RAM address C4000)

The factory sets the switches for memory address C000(hex) for an IBM PC AT or other machine with a 16-bit bus. If you're running on a PC XT or another 8-bit bus machine, or if you want to configure the scanner at an address other than C000(hex), you'll have to change the switches.

First set switches 7 through 10 to all closed for a PC AT or similar, all open for a PC XT or similar. The factory setting is all closed, for a PC AT or other machine with a 16-bit bus.

Next set switches 1 through 6 for the memory address you selected. Table 3.C shows the correct setting of switches 1 through 6, in that order, for every hex address below F000, where o is an open switch and c is a closed switch:

Table 3.C
Dip Switch Settings for Memory Address (Switches 1 through 6)

Hex Address	Switch Setting	Hex Address	Switch Setting	Hex Address	Switch Setting
0400	Occ ccc	5000	ccO cOc	A000	ccc OcO
0800	cOc ccc	5400	OcO cOc	A400	Occ OcO
0C00	OOc ccc	5800	cOO cOc	A800	cOc OcO
1000	ccO ccc	5C00	OOO cOc	AC00	OOc OcO
1400	OcO ccc	6000	ccc OOc	B000	ccO OcO
1800	cOO ccc	6400	Occ OOc	B400	OcO OcO
1C00	OOO ccc	6800	cOc OOc	B800	cOO OcO
2000	ccc Occ	6C00	OOc OOc	BC00	OOO OcO
2400	Occ Occ	7000	ccO OOc	C000	ccc cOO
2800	cOc Occ	7400	OcO OOc	C400	Occ cOO
2C00	OOc Occ	7800	cOO OOc	C800[1]	cOc cOO
3000	ccO Occ	7C00	OOO OOc	CC00	OOc cOO
3400	OcO Occ	8000	ccc ccO	D000	ccO cOO
3800	cOO Occ	8400	Occ ccO	D400	OcO cOO
3C00	OOO Occ	8800	cOc ccO	D800[2]	cOO cOO
4000	ccc cOc	8C00	OOc ccO	DC00	OOO cOO
4400	Occ cOc	9000	ccO ccO	E000	ccc OOO
4800	cOc cOc	9400	OcO ccO	E400	Occ OOO
4C00	OOc cOc	9800	cOO ccO	E800	cOc OOO
		9C00	OOO ccO	EC00	OOc OOO

1 Not available for the IBM PC XT

2 Recommended for IBM PC AT computers with EGA and VGA graphics

Plugging in the Board

The scanner board requires two slots. (Any two adjacent slots will do: the board doesn't have to be plugged into any particular slot.) The Installation and Setup manual from IBM, or the corresponding manual from the maker of your host computer, explains in detail how to install any add-on board. (See the Internal Option Installation Instructions section in the IBM manual.)

Host Bus Speed

The scanner is designed to operate on a standard 6 to 8 Mhz IBM AT bus. Newer 386 PC compatibles operate their busses at faster rates (11 or 12 Mhz) with no wait states. The scanner will not synchronize properly at these higher rates and will return a 102 error code at the completion of the setup command. Most of the faster 386 PC compatibles have a setup screen that allows you to choose the standard IBM AT bus speed. The standard bus speed must be chosen in order for the scanner to operate properly.

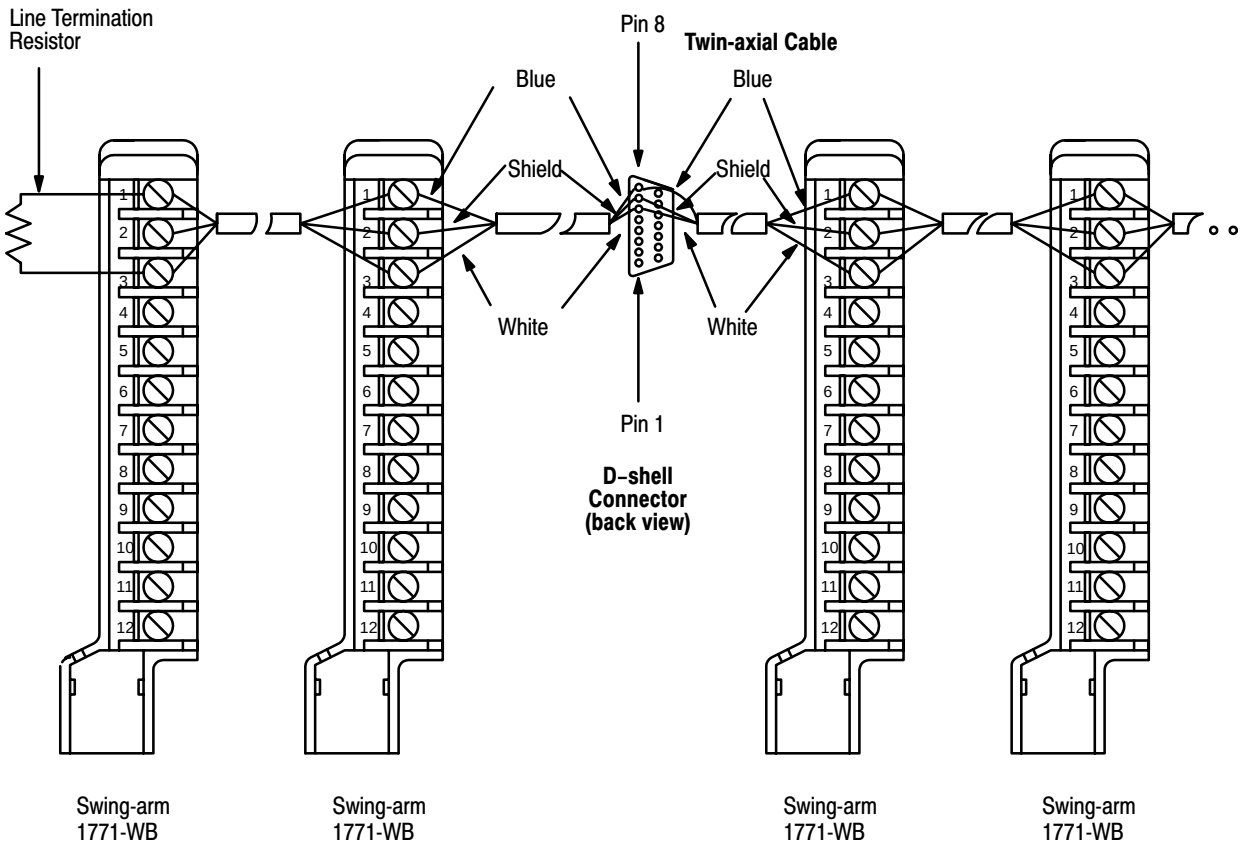
Attaching the I/O Cable

The 1771 Series I/O cable (the "blue hose") terminates in a 15-pin female D-shell connector, and the scanner has a 15-pin male connector accessible through the rear cover of the host computer. Connect the cable to the scanner and your installation is complete.

Table 3.D
1771 I/O Cable Connections

Scanner:	Cable:	Adapter:
pin 8	blue	terminal 1
pin 7	shield	terminal 2
pin 6	clear	terminal 3

Figure 3.3
Connecting 1771 I/O Cable in Parallel

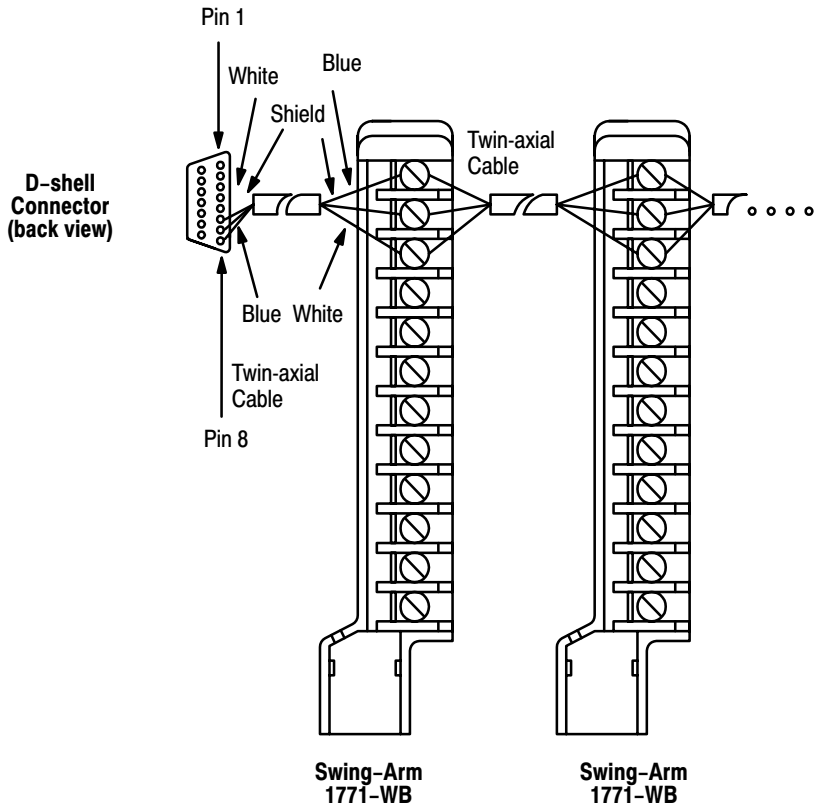


Note:

- Use the setup command to disconnect the shunt-line termination resistor in the scanner.
- You can connect a maximum of 16 swing-arms.
- Use termination resistor on the last swing-arm.

14864

Figure 3.4
Connecting 1771 I/O Cable in Series



Note:

- Use the setup command to disconnect the shunt-line termination resistor in the scanner.
- You can connect a maximum of 16 swing-arms.
- Use termination resistor on the last swing-arm.

14865

Chapter 4

Programming Overview

Chapter Objectives

This chapter gives you a general overview of the programming process. After reading this chapter you should be able to:

- identify the purpose of every file on your distribution disk
- install the software on your hard disk (if you have one)
- recognize the special features of source code for a program that interfaces with the scanner
- select names for your variables that won't conflict with the names in the programs we supply
- select the necessary options to compile and link a scanner interface program.

Disk Inventory

The host software is shipped on a single 720K (3.5") diskette, for use with Borland and Microsoft compilers. The disk contains an include file required with all your programs; run–time libraries in the small, compact, medium, large, and huge memory models; and source and executable code for the diagnostic program described in chapter 10, *User Diagnostic Program*.

The host software package also includes two 360K 5.25-inch diskettes, one for use with Borland compilers and the other for use with Microsoft compilers. The combined contents of these two diskettes is identical to the contents of the 720K diskette.

Table 4.A lists the contents of the host software package.

Table 4.A
Contents of Host Software Package

File:	Contents:
H_6008SI.H	include file
6008SI?M.LIB	run–time libraries compiled with Microsoft C 6.0A
6008SI?B.LIB	run–time libraries compiled with Borland C++ 2.0
U_D1M.EXE	user diagnostic program (Microsoft C version)
U_D1B.EXE	user diagnostic program (Borland C version)

Table 4.B lists the rest of the files that make up the source code for the user diagnostic program:

Table 4.B
Source Code for the User Diagnostic Program

File:	Contents:
U_D1.C	main program
U_D1.H	include file for the U_*.C files
U_BT.C	single block transfers
U_BTC.C	continuous block transfers
U_BTM.C	multiple block transfers
U_DISC.C	full-screen discrete I/O
U_GET.C	keyboard handler
U_GROUP.C	single-group discrete I/O
U_MR.C	management requests
U_PICK.C	main menu

We provide the diagnostic program source files so that you have extended examples of successful programming for the scanner. You should feel free to experiment by modifying them, though we cannot support any modified program versions.

Important: All of the files on the diskettes are Copyright (c)Allen-Bradley Company and may not be distributed or copied (other than from the distribution disk to your hard-disk or working diskette) without our permission.

All of the source files are identical between the two diskettes. The run-time libraries are different and have different names, as explained below. The executable programs work the same, but contain different code because they were compiled with different compilers.

If your system is equipped with a hard disk, please read the installation hints for the Borland or Microsoft version, below. (We provide hints rather than firm instructions because your hard disk could be organized in many ways for system development.)

If your system doesn't have a hard disk, you can write and run scanner programs using just floppy drives. Please consult your compiler and linker manuals for instructions on organizing your floppy disks.

Installing the Borland Version

This section provides installation suggestions. Feel free to modify this procedure according to your own configuration.

Important: We recommend that you make backup copies of the distribution disks and keep the originals in a safe place, away from your computer and away from stray magnetic fields.

Please make sure that your compiler is installed according to Borland's instructions before you follow the procedure below.

If you have a:	Then:
3.5-inch floppy-disk drive	Write protect the supplied 720K diskette (or your backup copy) by sliding the write–protect tab so that a hole shows through the diskette casing. Insert the diskette in the floppy-disk drive.
5.25-inch floppy-disk drive	Write protect the supplied 360K diskette labeled 'Borland C version' (or your backup copy) by applying a standard adhesive foil write–protect tab. Insert the diskette in the floppy-disk drive.

In the command examples below, we assume you're using the a: drive, so please substitute b: if appropriate. We also assume that your hard disk is drive c: — again, please substitute another drive letter if appropriate.

There are two main approaches: either copy the scanner's include file and libraries into the directories with the compiler–supplied files, or copy the scanner files into the work directory where you'll be developing software.

Method 1: Scanner files in same directories as compiler files

1. Change to the root directory for the compiler. If you used Borland's default installation, the command will be one of the following:

- for Borland C++ 2.0: `cd \borlandc`
- for Turbo C++ 1.0: `cd \tc`

The command will be different if you performed an installation to a directory other than Borland's default.

2. Copy the header file and libraries, like this:

```
copy a:h_6008si.h c:include
copy a:6008si?b.lib c:lib
```

You'll see five libraries copied, for the small, compact, medium, large, and huge memory models.

3. Create your development directory using the md command, and change to that directory by using the cd command.

4. Create an EXAMPLES directory under your development directory, using this command:

```
md examples
```

5. Copy the user diagnostic program (source code and executable) to this directory by typing the commands

```
copy a:u*.? c:examples
copy a:u_d1b.exe c:examples\u_d1.exe
```

If you wish, you can print the source files (approximately 35 pages) by using this command:

```
print examples\u_*.?
```

Method 2: Scanner files in development directory

1. Create your development directory using the md command, and change to that directory by using the cd command.

2. Copy the header file and libraries, like this:

```
copy  a:h_6008si.h  c:
copy  a:6008si?b.lib  c:
```

You'll see five libraries copied, for the small, compact, medium, large, and huge memory models.

3. Create an EXAMPLES directory under your development directory, using this command:

```
md examples
```

4. Copy the user diagnostic program, source code and executable, to this directory by typing these commands:

```
copy a:u*.? c:examples
copy a:u_d1b.exe c:examples\u_d1.exe
```

If you wish, you can print the source files (approximately 35 pages) by using this command:

```
print examples\u_*.?
```

Installing the Microsoft Version

This section provides installation suggestions. Feel free to modify this procedure according to your own configuration.

We recommend that you make backup copies of the distribution disks and keep the originals in a safe place, away from your computer and away from stray magnetic fields.

Please make sure that your compiler is installed according to Microsoft's instructions before you follow the procedure below.

If you have a:	Then:
3.5-inch floppy-disk drive	Write protect the supplied 720K diskette (or your backup copy) by sliding the write–protect tab so that a hole shows through the diskette casing. Insert the diskette in your diskette drive.
5.25-inch floppy-disk drive	Write protect the supplied 360K diskette labeled 'Microsoft C version' (or your backup copy) by applying a standard adhesive foil write–protect tab. Insert the diskette in your diskette drive.

In the command examples below, we assume you're using the a: drive, so please substitute b: if appropriate. We also assume that your hard disk is drive c: — again, please substitute another drive letter if appropriate.

There are two main approaches: either copy the scanner's include file and libraries into the directories with the compiler–supplied files, or copy the scanner files into the work directory where you'll be developing software.

Method 1: Scanner files in same directories as compiler files

1. Change to the root directory for the compiler. If you used Microsoft's default installation of C 6.00, the command is:

- for Microsoft C 6.0: `cd \c600`

If you have an earlier version of Microsoft C, or installed Microsoft C 6.0 to a non–default directory, the proper cd command depends on the directory you chose when you installed the compiler.

2. Copy the header file and libraries, like this:

```
copy a:h_6008si.h c:include
copy a:6008si?m.lib c:lib
```

You'll see five libraries copied, for the small, compact, medium, large, and huge memory models.

3. Create your development directory using the md command, and change to that directory by using the cd command.

4. Create an EXAMPLES directory under your development directory, using this command:

```
md examples
```

5. Copy the user diagnostic program (source code and executable) to this directory by typing these commands:

```
copy a:u*.? c:examples
copy a:u_d1m.exe c:examples\u_d1.exe
```

If you wish, you can print the source files (approximately 35 pages) by using this command:

```
print examples\u_*.?
```

Method 2: Scanner files in development directory

1. Create your development directory using the md command, and change to that directory by using the cd command.

2. Copy the header file and libraries, like this:

```
copy a:h_6008si.h c:
copy a:6008si?b.lib c:
```

You'll see five libraries copied, for the small, compact, medium, large, and huge memory models.

3. Create an EXAMPLES directory under your development directory, using this command:

```
md examples
```

4. Copy the user diagnostic program, source code and executable, to this directory by typing these commands:

```
copy a:u*.? c:examples
copy a:u_d1m.exe c:examples\u_d1.exe
```

If you wish, you can print the source files (approximately 35 pages) by using this command:

```
print examples\u_*.?
```

Writing Your Program

In chapters 5 through 9, we'll explain the details of writing application programs to communicate with the scanner. But first we'll give you a bird's-eye view.

Header Files

Every source program must contain these two lines:

```
#include <stdio.h>
#include <H_6008SI.H>
```

STDIO.H is the standard header file supplied with your compiler. **H_6008SI.H** is supplied on your scanner driver disk and defines constants, variables, and functions that your program needs.

Your program may need other header files in addition to these two. If so, you can add **#include** lines before or after the reference to **H_6008SI.H**. However, **H_6008SI.H** must come later in your source file than **STDIO.H**.

Program Skeleton

Before making reference to any other routines in the scanner driver library, your program must call either **setup_6008** or **start_6008** as described in chapter 5, Startup.

After the last reference to other library routines, but before exiting, you must call the **stop_6008** function; please see the "Shutdown" section of chapter 5. If your program crashes or exits normally without calling **stop_6008,** you may have to reset the host computer (`Ctrl-Alt-Del` or cycle power) to continue operating.

Between the startup and shutdown calls, your program must use the **host_active** macro to tell the scanner that your program is still active. By default, your program must do this at least once a second, but you can change the interval through programming. For full discussion of safety issues and programming, please see chapter 5, Host Watchdog.

Here's a sample program skeleton:

```
#include <stdio.h>
#include <h_6008si.h>
void main(argc, argv)
int argc;  char *argv[  ];
{


        QMR pkt;
        . . .
        status = setup_6008(1, 1, 3, 0, &pkt);

        if ( status != OK ) {
                printf("setup failed: command=%s  status=%s\n",
                        xlat_cmd(status), xlat_conf(pkt.qmr_stat));

                if ( status != C_AUTOCONF && status != C_SETUP )
                        printf("scanner fatal error %d\n", fatal_6008(
));
                abort( );
        }
        . . .
        /*  application logic here, including calls to host_active( )
        */
        . . .
        stop_6008( );


}
```

As explained in chapter 5, if setup fails the **setup_6008** function returns the number of the failed command and leaves the specific error status in the packet. The sample above above uses **xlat** routines, described in chapters 7 and 9, to display the meanings of the codes in plain English.

Once the setup procedure has succeeded, the scanner and host are talking and your program can proceed. Your program must call **host_active** as explained above.

Also, your program should periodically monitor global variable **g_act_scnr** to make sure that communications are still active. (Refer to chapter 5, Scanner Status, for complete information on **g_act_scnr** and other scanner monitoring features.)

Defined Constants

In their appropriate places in this manual we'll tell you about various constants defined in the header file **H_6008SI.H.** There are three constants that are not used by our routines but are defined for your convenience, and we'll list them now:

- **MAXGROUP** is the maximum number of module groups, 64. Groups in the I/O image tables are therefore numbered from 0 to **MAXGROUP-1**.
- **MAXMOD** is the maximum number of modules or slots, 132.
- **MAXADAPT** is not the maximum number of adapters (which is 16) but the number of possible adapter addresses, 32. (An adapter address is the same as a quarter-rack address, 8 x rack +group / 2.) For instance, when specifying fault dependent groups (chapter 7, "Scanner Management") you'll give **MAXADAPT** group numbers to account for everywhere an adapter might be addressed.

Defined Type Bool

It's convenient to think of several variables and function values as Boolean: that is, their value can be only true or false. We define the type **Bool** for such values. **Bool** is equivalent to **int**, but use of a specially defined type provides better program documentation.

We also define the two **Bool** constants **OK** and **NOT_OK**, equivalent to 0 and 1 respectively. This definition reflects the C language convention that 0 indicates no error and a nonzero value indicates an error.

Several library routines return status of **OK** or **NOT_OK,** and you can also use those constants in your program. An example is presented in the user diagnostic program source code, which we explain next.

Extended Example

Your distribution disk contains a complete sample program that exercises all aspects of the scanner operation through commands you enter from the keyboard. (Chapter 10, "User Diagnostic Program," is a user's guide for the **U_D1** program.)

Please take a minute to look at the source code for the main module, **U_D1.C.** The program includes header files **STDIO.H** and **H_6008SI.H** indirectly, through header file **U_D1.H**.

The main program displays identification on the screen and then calls **options** (in the same source file) to read and interpret command line options.

Next the main program calls **init** (also in the **U_D1.C** source file). In turn, **init** calls **setup_6008** and checks for status. If the setup was unsuccessful, **init** displays a message and abort execution rather than returning to **main**.

If setup succeeded, **init** returns control to **main**. The main program then goes into a loop that monitors the scanner activity code **g_act_scnr** and calls **pick** (in source file **U_PICK.C)** to get a command from the keyboard.When you enter a command to quit the program, **pick** returns a status of **NOT_OK** to the main program, which terminates the main program loop. The main program then calls **stop_6008** and exits.

You'll notice that we declare **init** and **options** as **Bool** type functions: they'll be returning a value of **OK** or **NOT_OK**. **pick** is declared **Bool** (in the header file **U_D1.H.**) We also have a **Bool** variable called **status** that we use as an "OK to proceed" sentinel. As soon as **status** takes on a value of **NOT_OK** the remaining code is bypassed until the **stop_6008** shutdown call.

You may also notice what looks like a violation of the rule we stated earlier, that **setup_6008** or **start_6008** must precede calls to any other routines in our library, and that no calls can follow **stop_6008.** Actually, we oversimplified that rule when we stated it. The true rule is that **setup_6008** or **start_6008** must be the first call that interacts with the scanner and **stop_6008** must be the last. But it's OK to call any of the following routines before startup or after shutdown: **sysdate**, **systime**, **sysstamp**, **pr_array**, **pr_globl** (though some values displayed may not be meaningful)**, xlat_cfg**, **xlat_cmd**, **xlat_conf**, **xlat_flt**, **xlat_opst**.

Avoiding Compile Time Name Conflicts

When you write your program, you need to make sure that the variable names you pick don't conflict with the variable names in our library or your compiler's library. This section and the next tell you how to avoid conflicts with our names; please consult your compiler manual for hints on avoiding conflict with its names.

File **H_6008SI.H** defines constants according to a logical pattern. The first few letters of each constant's name tells you how it's used, as follows:

Constant:	Definition:
C_	scanner commands (listed in chapter 7, Executing a Management Request, and chapter 8, Queueing a Block Transfer)
CM_	scanner operating modes (program, test, and run; listed in chapter 7)
SC_	confirmation status values (listed in chapters 7 and 8, Confirmation Status Codes)
SF_	fault status bits and values (listed in chapter 7, Autoconfigure and Link Status Information)
SL_	link (adapter) configuration status bits and values (listed in chapter 7, Autoconfigure and Link Status Information)
SO_	operating status bits (listed in chapter 5, Scanner Status)
MAX	user program limits (listed above, in Defined Constants)

C compilers treat capitals and lower case differently, so it's OK to select names that begin with **c_**, **cm_**, and so on. But stay away from local or global variable names beginning with any of the above character sequences in capitals.

Avoiding Link Time Errors

You eventually link one of our supplied libraries with your program. Please plan now to avoid naming conflicts. (You need to be concerned only with the names of your functions and **extern** variables. Your **static, auto,** and **register** variable names can't conflict with ours.)

Link time name conflicts could show up in two ways. The linker could refuse to create an executable program. But most likely the link would proceed with no indication of anything wrong, and your routine would be linked in and exclude our routine (or the compiler's library routine) of the same name. Then your program would crash (or give wrong results) when one of our routines called your routine instead of the "standard" routine. Bugs like these can be hard to uncover, so it's best to avoid them in the first place. Borland's TLINK linker offers the /d option to diagnose this sort of problem. We recommend you use the /d option if you're using Borland's Turbo C++ or Borland C++ to develop your application.

In this manual you'll see the names of almost all the functions in the libraries we supply, and naturally you should not use any of those names for your own code. In addition, the libraries have a few internal support routines whose names begin with **io_** or **IO_**, and you should avoid those names also.

Names of global variables in our libraries begin with **g_**. In addition, the libraries contain a number of undocumented internal global variables whose names begin with **_q**.

In summary, you can create conflicts with names in our libraries by naming functions and **extern** variables beginning with **g_, _q, io_,** or **IO_**. To be safe, stay away from those names and from the names of functions documented in this manual.

Compiling and Linking the Borland C++ 2.0 Version

These notes present a simple way of compiling and linking your application program with the scanner code. This way may or may not be the best way for your development. There are many alternatives – Borland's Integrated Development Environment, make files and project files, and so on. You should evaluate the alternatives and decide which way is most productive for you.

Decide which memory model you will use (small, compact, medium, large, or huge). Please see the discussion of memory models in your compiler manual. In the command below, replace %%%% with the first letter of the memory model, in lower case.

Use this command to compile and link your program in one step:

```
BCC -N -K -w -m%%%% -lcd yourprogname.c 6008si%%%%b.lib
```

Important: –lcd upper/lower case is significant in public names; diagnose duplicate names in libraries.

The options we recommend are listed in Table 4.C.

Table 4.C
Options for Compile and Link

Options:	Description:
–N	stack checking turned on
–K	default 'char' is 'unsigned char'
–w	show warnings at compile time
–m	select memory model
–O	turn off optimization
–d	set up for debugging
–v	link with debugging information

We recommend against the –a option (align structure members by word). Our library routines were compiled without it, and may not be compatible with code you compile with that option.

For information on selecting or excluding the 8087 or 80287 math coprocessor, please see the Borland manual sections on the –f options. Our libraries are compatible with any –f option because they contain no floating-point operations.

Example 1: Your program is called APPLIC.C. You have selected the small (s) memory model. The combined command to compile and link would be

```
BCC –N –K –w –ms –lcd applic.c 6008sisb.lib
```

Borland C++ will compile applic.c as applic.obj and link it as applic.exe.

Example 2: If your program is in several source modules, you can list them on the command line. If you have chosen medium model, the command is

```
BCC –N –K –w –mm –lcd control.c contr1.c contr2.c 6008simb.lib
```

The three source files will be compiled and linked as CONTROL.EXE.

Example 3: You have many source files — U_D1.C, U_BT.C, and so on — to be compiled and linked in a program called U_D1B.EXE. Header files are not in the same directory as source code, but are in directory c:\dev\hdr. The following command will compile and link in small model.

```
BCC –N –K –w –ms –lcd –Ic:\dev\hdr –eU_D1B U_*.C 6008sisb.lib
```

This is quite similar to the command we used to create the U_D1B program on your distribution disk.

Compiling and Linking the Borland Turbo C++ 1.0 Version

The procedure is exactly the same as for Borland C++ 2.0, except that you begin the command with TCC rather than BCC.

```
TCC –N –K –w –m%%%% –lcd yourprogname.c 6008si%%%%b.lib
```

Compiling and Linking the Microsoft C 5.1 or 6.0 Version

These notes present a simple way of compiling and linking your application program with the scanner code. This way may or may not be the best way for your development. There are many alternatives – Microsoft's Programmer's Workbench, make files, and so on. You should evaluate the alternatives and decide which way is most productive for you.

Decide which memory model you will use (small, compact, medium, large, or huge). Please see the discussion of memory models in your compiler manual. In the command below, replace %%%% with the first letter of the memory model, in upper case.

Use this command to compile and link your program in one step:

```
CL /J /A%%%% /W3 yourprogname.c /link 6008si%%%%m
```

The options we recommend are listed in Table 4.D.

Table 4.D
Options for Compile and Link

Options:	Description:
/J	default 'char' is 'unsigned char'
/A	select memory model
/W3	show warnings at compile time
/link	select scanner library
/Od	turn off optimization
/Zi	set up for CodeView debugging

We recommend against the /Zp option (pack structure members). Our library routines were compiled without it, and may not be compatible with code you compile with that option.

For information on selecting or excluding the 8087 or 80287 math coprocessor, please see the Microsoft manual sections on the /FP options. Our libraries are compatible with any /FP option because they contain no floating–point operations.

Example 1: Your program is called APPLIC.C. You have selected the small (S) memory model. The combined command to compile and link would be

```
CL /J /AS /W3 applic.c /link 6008sism
```

Microsoft C will compile applic.c as applic.obj and link it as applic.exe.

Example 2: If your program is in several source modules, you can list them on the command line. If you have chosen medium model, the command is

```
CL /J /AM /W3 applic.c /link 6008simm
```

The three source files will be compiled and linked as CONTROL.EXE.

Example 3: You have many source files — U_D1.C, U_BT.C, and so on — to be compiled and linked in a program called U_D1M.EXE. Header files are not in the same directory as source code, but are in directory c:\dev\hdr. The following command will compile and link in small model.

```
CL /J /AS /W3 /FeU_D1M /Ic:\dev\hdr U_*.C /link
6008sism
```

This is quite similar to the command we used to create the U_D1M program on your distribution disk.

Further Information

The next few chapters of this manual explain programming features:

- Chapter 5, Startup, Status, and Shutdown, explains features that must be in every scanner interface program, including how to start and stop scanner operation, status monitoring, and the host watchdog.
- Chapter 6, Discrete I/O, explains how to read single-point inputs and write outputs.
- Chapter 7, Scanner Management, explains how to issue management requests that modify the operation of the scanner.
- Chapter 8, Block Transfer, explains how to read data from, and write data to, intelligent I/O modules.
- Chapter 9, General Support Features, explains how to write timing loops, time-stamp a file or printout, and translate a numeric scanner command to English.

The last two chapters are concerned with diagnostics:

- Chapter 10, User Diagnostic Program, tells you how to use the diagnostic program that we included on your distribution disks.
- Chapter 11, Troubleshooting, has some questions and answers to help you in diagnosing problems.

Chapter 5

Startup, Status, and Shutdown

Chapter Objectives

This chapter explains features that must be in every scanner program. After reading this chapter, you should be able to write code that:

- tells the scanner to start operation
- lets the scanner know that your program is still active (the host watchdog)
- makes sure that the scanner is still active
- checks the current operating status of the scanner
- shuts down scanner operation in a way that leaves the scanner ready for when your program runs again.

Overview

Every application begins with a call to **setup_6008** or **start_6008.** Every application makes one or more calls to **host_active** to satisfy the host watchdog. Applications should check global variable **g_act_scnr** periodically to make sure that the scanner is still active, though this is not enforced. If your program finds from **g_act_scnr** that the scanner is no longer active, you can call **fatal_6008** to find out why. Finally, every application must call **stop_6008** before exiting.

CAUTION: If you are running a real-time control program, screen dumps `[Shift-PrtSc]` cause the scanner to lose communication with the host computer. Adapters on the I/O link go to Last State or Reset, depending on their switch settings. You must restart your system to re-establish communication.

Startup

In this section we'll look at two functions that start the scanner and the host talking to each other: **start_6008** and **setup_6008.** Every application uses one or the other, but not both. For most applications we recommend **setup_6008,** which does more and is easier to use than **start_6008.**

Common Features

Both routines start the host watchdog, which your program must service regularly. See chapter 5, "Host Watchdog", for more information.

Both routines also load the global variables **g_ver_scnr** and **g_ver_host,** which are strings identifying the release of the scanner firmware and of the host software driver. The scanner firmware version string **g_ver_scnr** is no more than 39 characters long (38 plus the terminating zero byte), and the host version string is 69 characters long (68 plus the zero byte). Your program should display these strings so, that in case of trouble, you have the information to give to A-B Technical Service.

setup_6008

setup_6008 initializes the interrupt handler and the global variables, establishes communication with the scanner in program mode, and does the initial baud and resistor setup (if required) and initial autoconfigure. (For the meaning of autoconfigure, please see that section in chapter 7, Scanner Management.)

Note: In the management request **C_SETUP** command, **-1** indicates no change.

Calling sequence:

```
status = setup_6008(baud, resistor, irq_l, segment, &packet);
```

Arguments:

- *baud:* an integer representing the baud rate multiplier applied to the board's base rate of 57.6 Kbaud. At present only 1 and 2 are legal, for 57.6 and 115.2 Kbaud; or use -1 which means the default, 57.6 Kbaud.
- *resistor:* an integer whose value is 1 if the line termination resistor is connected and 0 if not; -1 means the default, resistor connected.
- *irq_l:* an integer whose value is 3, 5, 10, or 12, depending on the hardware interrupt line desired; -1 means the default, IRQ3, is selected.
- *segment:* an unsigned representing the segment or paragraph address of the global RAM. (Drop the final zero from the actual address to obtain the paragraph address, which is the argument to this routine.) A

value of 0 for this argument defaults to the factory-selected paragraph address of C000h. Switches on the board are set to determine the global RAM's address in the host's memory space, as explained in chapter 3, *Installation*.

- *packet:* a **QMR** packet, (see chapter 7, *Scanner Management*) into which **setup_6008** returns the autoconfigure information, or status in case of error. Note that the argument is a pointer to the packet.

Returned values:

- **status:** an integer**: SC_OK** 0(hex) if the setup proceeded without error, **C_AUTOCONF** 10(hex) if the initial autoconfigure failed, **C_SETUP** 13(hex) if the setup call (changing baud rate or resistor) failed; any other value means that the initial sync with the scanner failed.

- If the returned value is **SC_OK,** your program's packet contains the information regularly returned by an autoconfigure.

- If the returned value is anything but **SC_OK,** the specific nature of the error is in the **qmr_stat** field of the packet that you passed to **setup_6008.** Your program should display status information and abort immediately.

Here's the start of a sample program, showing a call to **setup_6008** and associated checks for error:

```
#include <stdio.h>
#include <h_6008si.h>
void main( )
{
   QMR pkt;
    int status;
    . . .
    status = setup_6008(-1, -1, -1, 0xC400, &pkt);
    if ( status != OK ) {

        printf("setup failed: command=%s  status=%s\n",
              xlat_cmd(status), xlat_conf(pkt.qmr_stat));
        if ( status != C_AUTOCONF && status != C_SETUP )
              printf("scanner fatal error %d\n", fatal_6008(
));
        abort( );
}
else
  mr_print(stdout, C_AUTOCONF, &pkt);
. . .
```

The declaration, **QMR pkt,** is explained in chapter 7, *Data Structure*.

Look at the call to **setup_6008.** The first two arguments select the default baud rate (57.6 Kbaud) and resistor setting (connected). The next two arguments give the default interrupt request line setting (IRQ3) and the paragraph address of the scanner, C400 (hex), which corresponds to C400 in the table in chapter 3, Installation. The fifth argument points to the packet, which contains autoconfigure information if setup was successful and an error code if it was not.

Next we test the status returned by **setup_6008.** If it's not equal to **OK** (or **SC_OK;** the two constants have the same value), we have a problem. In this case the status is the number of the command that failed, and we display a message using the translation routines described in chapter 9, General Support Features, and chapter 7, Scanner Management. If the status is neither **C_AUTOCONF** not **C_SETUP,** the host was unable to establish communication with the scanner and the **fatal_6008** routine gives a code for the reason. If we couldn't complete the setup operations, we abort execution of the program.

NOTE: A common error returned from the **fatal_6008** function is error code 102. This usually means the RAM address set with the dip switches on the scanner does not agree with the address argument in the **setup_6008** function. Code 102 can also mean an addressing conflict with other hardware in your PC. For most PC's D800(hex) is usually free. Also make sure the bus speed of your PC is not running faster than 8 Mhz.

If the setup operation did succeed, the host and the scanner are now talking and your application program can proceed. In this example, we use **mr_print** to display the initial configuration information.

The scanner is in program mode upon startup, and you'll probably want to change to run mode. For that procedure, see Set Operating Mode in chapter 7, Scanner Management.

start_6008

This function does a partial setup. Your program would call this function rather than **setup_6008** only when for some reason you want to synchronize with the scanner but not set the baud rate and resistor and not do an initial autoconfigure.

Calling sequence:

```
status = start_6008(irq_l,segment);
```

Arguments:

- *irq_l:* same as under **setup_6008** above.
- *segment:* same as for **setup_6008** above.

Returned values:

- status: **SC_OK** 0(hex) if the sync proceeded without error, **SC_PENDING** FF(hex) if the sync timed out, **SC_NOT_OK** 01(hex) if the segment argument was illegal, **SC_BAD_REQ** 10(hex) if the scanner had already been synchronized earlier in this execution, **SC_BAD_VERSN** FE(hex) if the scanner firmware series didn't match the host, or a confirmation error status returned from the scanner.
- If the returned status is anything but **SC_OK,** your program should display the status value and the value of function **fatal_6008,** then abort execution.

Host Watchdog

Please refer to the Host Watchdog section in chapter 2, I/O Scanner Concepts. That section explained the general concepts, this section explains the specific programming steps.

host_active

This macro sets the host watchdog to a user- specified interval or to the default.

By default, your program must call the **host_active** macro at least once a second (18 units of 55 ms). You can select a different interval in any **host_active** call**,** to be effective for that call only.

Calling sequence:

`host_active(`*interval*`);`

Arguments:

- *interval:* a positive integer specifying the interval, zero to select the default interval, or a negative value to disable the watchdog. Please see the discussion below.

Returned values:

- none.

g_act_host

When you call **host_active**, the specified positive number (or 18 if the actual argument is zero) is placed in the global variable **g_act_host.** Then every 55 ms the timer interrupt counts **g_act_host** down a notch. When the scanner interrupts the host, the interrupt handler checks **g_act_host** and if it's negative the interrupt handler infers that the host program is not active. The scanner goes off the link within 50 ms, all adapters go inactive, and output terminals go to last state or reset. So your program could bypass the **host_active** macro and just update **g_act_host,** but the macro provides convenient program documentation.

You can disable the host watchdog by a one-time call to **host_active** with a negative argument (which stores 0 in **g_act_host**). This may be appropriate for strictly monitoring applications, but it's almost certainly a bad idea for control applications. You should be aware that disabling the watchdog overrides the last state or reset switches and effectively sets all discrete outputs at last state in case of a program failure.

Scanner Status

This section tells you about three ways your program can monitor the status of the scanner:

- Global variable **g_op_stat** contains status bits that tell you the current scanner operating mode and fault conditions. You can use the function **xlat_opst** to convert the status bits to English.
- Global variable **g_act_scnr** is positive as long as the scanner is still in communication with the host.
- Function **fatal_6008** returns a code to describe the nature of the scanner shutdown after it is no longer communicating with the host.

g_op_stat

At any time after the initial call to **setup_6008** or **start_6008,** your program can monitor the unsigned variable **g_op_stat.** This variable is a set of bit fields, and you can test for a particular condition by ANDing a symbolic constant with **g_op_stat.**

For instance, **SO_FAULT** is the symbolic name of the bit field that is true (nonzero) when any adapters are faulted. To find out if any adapters are faulted, your program would use this statement:

```
if ( SO_FAULT & g_op_stat )
        /* one or more adapters are faulted */
else
        /* no adapters are faulted */
```

Table 5.A lists all of the bit fields in the global variable **g_op_stat:**

Table 5.A
g_op_stat bit field descriptions

Bit Field:	Hex Value:	Description:
SO_RUN	**04 (hex)**	The scanner is in run mode.
SO_PROGRAM	**01 (hex)**	The scanner is in program mode.
SO_TEST	**02 (hex)**	The scanner is in test mode.
SO_DEBUG	**08 (hex)**	The scanner is in debugging mode (scanner watchdog disabled). For more on the scanner watchdog, see chapter 2., *Scanner Watchdog*. For debugging mode, see chapter 7, *Setup*.
SO_BT_PEND	**20 (hex)**	One or more block transfers are pending in the scanner's queue.
SO_FAULT	**40 (hex)**	One or more adapters are in fault state.
SO_CHG_FLT	**80 (hex)**	The fault state of one or more adapters has changed. (This bit must be reset by your program; the driver never resets it.)
SO_OIT_ERR	**10 (hex)**	If set, this bit indicates that your program has written one or more valid module control bytes to the output image table, causing one or more unsolicited block transfers. (Once set on, this bit remains on until the user program resets it.) Please see chapter 8, *Unsolicited Block Transfer*, for more information.

As mentioned previously, the **SO_CHG_FLT** and **SO_OIT_ERR** bits are set by the driver but can only be reset by your program. Periodically, probably once per program scan, your program should monitor these bits.

If the fault-change bit, **SO_CHG_FLT,** is set, your program should then check **SO_FAULT** to determine the nature of the change. If the fault bit is not set, the nature of the fault change was that the last faulted adapter came back on line. But if the fault bit is set, your program should probably execute a link status command (see chapter 7, *Autoconfigure and Link Status Information*) to check which adapters are faulted. Here's some sample code, to be executed once per program scan:

```
if ( SO_CHG_FLT & g_op_stat ) {
    g_op_stat &= ~SO_CHG_FLT;
    if ( SO_FAULT & g_op_stat ) {
        mr_wait(C_LINKSTAT, &link_pkt);
        /* code to examine adapter status goes here */
    }
}
```

In the first line of this example we test whether the fault state of any adapters has changed; if so, we reset the fault-change bit. In the third line we test the fault bit, and if any adapters are faulted we execute a link status call to find out which ones. After the link status call, you would put code to test the fault bits for each adapter, as explained in chapter 7, *Autoconfigure and Link Status Information*.

For testing and resetting the **SO_OIT_ERR** bit (output image table programming error), please see chapter 8, *Unsolicited Block Transfer.*

xlat_opst

This function translates the operating status bits in **g_op_stat** to English.

Calling sequence:

```
explan = xlat_opst( );
```

Arguments:

None, since the operating status is a global variable.

Returned values:

- a character pointer whose object is a string suitable for printing. The string length does not exceed 80 characters (79 plus the terminating zero byte).

Note that **xlat_opst** has an internal string buffer and returns a pointer to that buffer. Calling **xlat_opst** destroys the previous contents of the buffer. This means that you must use the string returned by this routine before you call the routine again.

Here's a typical use of this routine:

```
printf("status: %s\n", xlat_opst( ));
```

g_act_scnr

This sentinel word (type integer) lets your program check periodically that the scanner is still talking with the host. Here's how it works.

This word is decremented once every 55ms; on the other hand, the interrupt handler resets the value to 12 every time an interrupt from the scanner is processed. Thus **g_act_scnr** goes negative about 1/3 of a second (12K x 55ms) after the scanner last talks to the host.

Your program should poll for scanner failure by executing code similar to the following once per program scan:

```
if ( g_act_scnr < 0 ) {
    print("\nscanner failure: code %d\n", fatal_6008( ));
    stop_6008( );
    abort( );
}
```

The **fatal_6008** and **stop_6008** functions are explained later in this chapter.

Note that **g_act_scnr** goes on decrementing even after the scanner stops talking to the host, so that it flips from negative to positive about half an hour later.

fatal_6008

This function obtains the scanner shutdown code, if available. Your program should call this function, and display its result, whenever **g_act_scnr** goes negative.

Calling sequence:

```
code = fatal_6008( );
```

Arguments:

- none.

Returned values:

- unsigned: 0 if the scanner is currently active, 1 if the scanner is inactive but the function can't obtain the actual code because the host doesn't have access to the global RAM (or because the scanner left no shutdown code), or a value greater than 1 if the error code is obtainable.

  If the global variable **g_act_scnr** is negative, either after a failed **setup_6008** or **start_6008** or at any other time during execution, **fatal_6008** may return a meaningful error code. In that case, your program should display the function value.

You should know about two special values that might be returned by **fatal_6008:**

- 101 means that the interrupt handler let the scanner shut down because your program hadn't called **host_active** recently enough. For more on this feature, please see chapter 5, "Host Watchdog".
- 102 means that your application program shut down interrupts properly through the **stop_6008** function, as described later in this chapter. This code usually means that one of the setup parameters in the SETUP command did not match the physical hardware setting of the scanner. Recheck the scanner's memory and interrupt configuration.

CAUTION: If you ever get an error code other than 0, 101, and 102 from **fatal_6008,** please call A-B immediately, because a hardware or firmware problem with the scanner may have occurred.

Shutdown

Why is shutdown required?

Your application program must shut down the scanner properly before exiting back to DOS. There are two reasons to do this:

- An orderly shutdown puts all output modules into last state or reset, according to the switches set on the I/O chassis. This would happen without an orderly shutdown, but would take about 100ms longer.
- When your program issued the original call to **setup_6008** or **start_6008,** the driver routines altered the DOS interrupt vectors to point to library routines linked in your executable file. The shutdown routine resets those interrupt vectors. If your program exits without resetting the interrupt vectors, and you then try to run a program that overlays the area pointed to by the altered interrupt vectors, the host computer may lock up or behave erratically, requiring a hard reset or cycling power before you can use it again.

stop_6008

This function de-installs the scanner interrupt code. If a **setup_6008** or **start_6008** function has once been executed successfully, your program **must** call this function before exiting.

Calling sequence:

```
stop_6008( );
```

Arguments:

- none.

Returned values:

- none.

Your program can omit the **stop_6008** call only if the initial **setup_6008** or **start_6008** call failed. However, an extra **stop_6008** call does no harm, even where it's not needed.

Chapter 6

Discrete I/O

Chapter Objectives

This chapter explains how to use the functions contained in the host software library to do discrete I/O. After reading this chapter, you should be able to:

- examine any discrete inputs
- set or clear any discrete outputs
- examine any outputs that you set or cleared previously.

You should be able to do all three of these either directly, by subscripting into the I/O image tables, or indirectly, by using the supplied library routines.

Direct Image Table Access

The output and input image tables are two unsigned integer arrays of 64 words each, named **g_oit** and **g_ipt** respectively. You can directly read either table using C language assignment statements, and you can directly write to the output image table in the same way. (You can write to the input image table to use unused input areas for storage. We do this frequently in programmable controllers. However, with all the memory available to you for storage in user RAM, we do not recommend using the input image area for storage.)

The techniques, discussed in this section for accessing discrete I/O, execute the quickest , but may be a little hard to understand. The techniques discussed later in this chapter (see ”Library Routines”), sacrifice some execution speed to gain some clarity. You’ll need to decide which techniques are best for your application.

WARNING: Whichever technique you use to set outputs, make sure that you don’t write to the output image table bytes that correspond to intelligent I/O (block transfer) modules. If you do write to these bytes, you’ll be unintentionally requesting a block transfer. For more details, please see chapter 8, ”Unsolicited Block Transfer”.

Subscript Calculation

The image tables are tables of words, where each 16-bit word corresponds to the 16 terminals of a module group. Terminal 17 octal (15 decimal) corresponds to bit 017 (15 decimal) of the word, and so on down to terminal 0 and bit 0. (16 bits times 64 words gives 1024 output terminals and 1024 input terminals. Though possible, it is very unlikely that any given application would use all I/O points.)

To address a particular module group in either the output or the input image table, the subscript is 8 times the rack plus the group. For instance, if you wanted to return the 16-bit contents of rack 2, group 7 from the input image table, you could code it this way:

```
value = g_ipt[8*2+7];
```

Single Terminal

To access a single input terminal, you need to shift the word value and AND a 1 to mask off the other bits. Remember to specify terminal numbers in decimal, or use a leading zero if you're specifying terminal numbers in octal.

Example: to obtain the value of terminal 12 octal (10 decimal) from rack 3, group 5, either of these statements works:

```
bit = g_ipt[8*3+5]>>012 & 1;  or
bit = (g_ipt[8*3+5]>>10) & 1;
```

The first statement as coded depends on the C language's operator priority: shifts are done before ANDs. You may feel more comfortable adding parentheses to emphasize the order of operations, as we did in the second statement.

If you're simply going to use a terminal value in an **if** test, you can shift it as we did above, or you can use a one bit mask like this:

```
if ( g_ipt[8*3+5] & (1<<012) ) . . .
```

This doesn't look much better than the previous construct, but if you define symbolic constants (as we recommend) the code becomes clearer:

```
#define SENS_RACK 3
#define SENS_GRP  5
#define SENS_BIT  012
#define SENS_MASK (1<<SENS_BIT)
        . . .
if ( g_ipt[8*SENS_RACK+SENS_GRP] & SENS_MASK ) . . .
```

To set a single output terminal, you simply OR a 1 bit in the appropriate position within the output image table word. Here's an example, for terminal 3 of rack 0, group 7:

```
g_oit[88*0+7] |=1<<3;
```

The next time the scanner scans that rack, the new value is transferred to the scanner's output image table and, the time after that, the value goes on the I/O link to the module.

To reset (clear) a terminal is a little trickier: you have to AND a mask that contains 1 bits everywhere except in the bit position of the terminal to be cleared. The C language operator ~ is made for this kind of operation:

```
g_oit[8*0+7] &= ~(1<<3);
```

Access by Byte

If you need to access one slot within a module group, say to reset all eight terminals in a single operation, you have two ways to do it. You could use a cast operator to access the image table as an array of 128 character values, or you could use the masking technique shown above.

Example: to clear slot 12 (the left hand slot of group 6) of rack 2, you can do either

```
g_oit[8*2+6] &= 0xFF00;   or
*((char *)g_oit + 16*2+12) = 0;
```

Notice in the first example that the low byte of a constant occurs at the right, even though the low slot is physically at the left in the chassis. (The bytes within a word are stored with the low byte at the lower address, backward from the way the numbers occur in computations.) In the second example, notice that we have 16 bytes rather than 8 words per rack.

Programming Hint

We suggest that you define constants for the addresses of your I/O modules. This makes your programs easier to understand, and helps you in debugging. For example:

```
#define ALARM_RACK 5
#define ALARM_GRP  0
#define ALARM_TERM 017
        . . .
g_oit[8*ALARM_RACK+ALARM_GRP] |= 1<<ALARM_TERM;
```

Let's look at this example. We defined the rack and group of the module that controls an alarm, and the specific terminal (note the leading zero for octal notation). To turn on an output terminal, we shifted a 1 bit left by the terminal number and ORed that into the output image table.

By the way, you may be wondering about efficiency. Most C compilers do all arithmetic on constants at compile time. So at run time there would be no difference in execution speed between the above statement and

```
g_oit[40] |= 0x8000;
```

but the first way is certainly easier to understand and maintain.

Library Routines

We provide you with several library routines and macros to access the I/O image tables. Execution is not as efficient as with the direct addressing techniques in the previous section, but the difference should be negligible in most applications compared to the time for transferring data across the link.

getbit

Use this routine to get a bit from the input or output image table.

Calling sequence:

```
value = getbit(inout, rack, group, bit);
```

Arguments:

- *inout:* the constant **IN** (1) for input image or **OUT** (0) for output image.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *bit:* an integer 0 to 15 (octal 0 to 017), the bit or terminal number.

Returned values:

- an integer, the value of the bit, 1 or 0.

  Example:

  ```
  sens_bit = getbit(SENS_RACK, SENS_GRP, SENS_BIT);
  ```

  obtains an on or off value from the sensor, assuming that you have defined the symbolic constants in your program.

getbyte

Use this routine to get an 8-bit byte from the input or output image table.

Calling sequence:

```
value = getbyte(inout, rack, group, hilow);
```

Arguments:

- *inout:* the constant **IN** (1) for input image or **OUT** (0) for output image.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *hilow:* the logical constant **HI** (1) or **LO** (0) to select the high or low byte. The high byte corresponds to slot 1 within a module group (terminals 017-010), and the low byte to slot 0 (terminals 07-00).

Returned values

- a character, the value of the byte.

getword

Use this routine to get a 16-bit word from the input or output image table.

Calling sequence:

```
value = getword(inout, rack, group);
```

Arguments:

- *inout:* the constant **IN** (1) for input image or **OUT** (0) for output image.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.

Returned values:

- an unsigned integer word, the value in the image table for that module group.

putbit

Use this routine to write a bit into the output image table.

Calling sequence:

```
putbit(data, rack, group, bit);
```

Arguments:

- *data:* an unsigned integer, whose low order bit is to be written to the output image table.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *bit:* an integer 0 to 15 (decimal) or 0 to 17 (octal), the bit number.

Returned values:

- none

setbit

Use this routine to write a one bit into the output image table.

Calling sequence:

```
setbit(rack, group, bit);
```

Arguments:

- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *bit:* an integer 0 to 15 (decimal) or 0 to 17 (octal), the bit number.

Returned values:

- none.

  Example:

  ```
  setbit(ALARM_RACK, ALARM_GRP, ALARM_TERM);
  ```

  turns on the alarm if the three constants have been defined with the rack, group, and terminal (bit) number.

  Note: **setbit** is a macro that compiles into a call on **putbit** with a constant data value of 1.

clrbit

Use this routine to write a zero bit into the output image table.

Calling sequence:

```
clrbit(rack, group, bit);
```

Arguments:

- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *bit:* an integer 0 to 15 (decimal) or 0 to 17 (octal), the bit number.

Returned values:

- none.

Note: **clrbit** is a macro that compiles into a call on **putbit** with a constant data value of 0.

putbyte

Use this routine to write an 8-bit byte to the output image table.

Calling sequence:

```
putbyte(data, rack, group, hilow);
```

Arguments:

- *data:* an unsigned integer whose low order byte is written to the output image table.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.
- *hilow:* the logical constant **HI** (1) or **LO** (0) to select the high or low byte. The high byte is slot 1 (terminals 17-10) of the module group; the low byte is slot 0 (terminals 07-00).

Returned values:

- none.

putword

Use this routine to write a 16-bit word to the output image table.

Calling sequence:

```
putword(data, rack, group);
```

Arguments:

- *data:* an unsigned integer to be written to the output image table.
- *rack:* an integer 0 to 7, the logical rack number.
- *group:* an integer 0 to 7, the module group number.

Returned values:

- none

Print or Display Image Table

This section describes a routine we provide to help you dump the input or output image table, or any array, to screen, printer, or disk. You can dump the array by byte (16 per line) or by word (8 per line).

pr_array

Use this routine to format a word or byte array for display.

Calling sequence:

```
pr_array(fileptr, header, array, length);
```

Arguments:

- *fileptr:* **stdout** or **stderr** for output to screen, or a pointer to a file opened by the user program through **fopen.**
- *header:* a character pointer whose object is a descriptive phrase of a few characters, such as “IIT”. If the display is to fit on an 80- character line, the length of the header string must not exceed 34 characters if the array is word oriented, 26 if byte oriented.
- *array:* the name of a character or unsigned integer array.
- *length:* an integer giving the length of the array. If the array is to be displayed as words, length should be a positive number. If the array is to be displayed as single bytes (type chararacter), length should be minus the number of bytes in the array.

Returned values:

- none.

Example: dumps the output image table by words to the screen.

```
pr_array(stderr, "output image", g_oit, MAXGROUP);
```

Example: dumps the scan list from a management request packet to a file by bytes. Here **filrec** is the value returned by an earlier call to the standard library routine **fopen,** which is supplied with your compiler.

```
pr_array(filrec, "scan list", pkt.qmr_data, -pkt.len);
```

Timing of Discrete I/O

It's important to bear in mind that when you update your output image table there is not an immediate effect on the outside world. (Though we talk about output in this section the same timing applies to input: it takes as long for a new input value to find its way from the input module to your program as it does for an output value to follow the reverse path.)

Here is the chain of events for an output:

- Your program updates **g_oit,** your output image table, either directly or by using a library routine.
- Some time later, the scanner interrupts the host.
- The host interrupt handler (which runs in background as far as your program is concerned) copies from the scanner's input image table to **g_ipt,** your input image table, and copies from **g_oit** to the scanner's output image table.
- If the interrupt occurred just after you changed the output, the new data is transferred when the scanner has run through its entire scan list back to the point of the last interrupt. (The scanner interrupts the host once per scan list to refresh I/O in both directions.)
- Later the scanner comes to the adapter associated with the changed data, and sends the new information to the adapter.

This sequence of events could take as long as two passes through the scan list. This worst case scenario happens when you update an output just after the scanner and the host interrupt handler have refreshed that rack. So it may take one cycle until the scanner gets the new value, and a second cycle until it services the adapter and sends the changed output.

How long is a cycle? Multiply 11 milliseconds (7 ms at 115.2 Kbaud) by the number of adapters in the scan list. Your program has no way to know where the scanner is in the scan list, or when the refreshes take place, so if timing is critical you must assume that outputs might not get out to the real world for as long as two complete scan lists if each adapter occurs only once. (You can improve the situation by putting a critical adapter at two different points in the scan list; see the scan list command in chapter 7, ”Scan List”.)

Partial Refresh

You can force a partial refresh sooner than the worst case of two complete passes through the scan list. This makes the scanner’s latest input information available to your program and send the scanner new discrete outputs for those same racks. However, your program has no way to update specific racks or adapters, or to know which racks have just been refreshed.

We don’t know of an application that would require such an interim refresh, but if you decide yours is one here is how to refresh the I/O image tables early.

Note: It may bear repeating that **update** merely updates I/O image tables; it does not assure your program that any I/O has actually occurred.

update

Use this routine to refresh the I/O image tables.

Calling sequence:

```
status = update( );
```

Arguments:

- none.

Returned value:

- **OK** if the scanner responded before the timeout period specified by **g_timout; NOT_OK** if the scanner did not respond.

This routine interrupts the scanner, then waits until the scanner has interrupted the host at least once. The host's interrupt handler updates the global RAM from the user program's output image tables and the user input image tables from the global RAM. After the interrupt has been processed, **update** returns control to your program.

Chapter 7

Scanner Management

Chapter Objectives

This chapter explains how to issue management requests to the scanner. After reading this chapter, you should be able to:

- queue any of the six types of management requests
- print or display the results, or write formatted results to a file.

To make this chapter shorter and easier to read, we use the abbreviation MR for management request.

Overview

Here is a summary of the actions involved in completing an MR:

- Your program puts the data (for all commands except autoconfigure and link status) and length of data (for scan list only) into a packet of specified structure.
- Your program calls the **mr_wait** library routine.
- **mr_wait** copies information to an internal queue and interrupts the scanner. **mr_wait** does not return to your program but instead goes into a wait loop, which ends when the request is done or **g_timout** units of time have elapsed.
- When the scanner responds (usually a short time later), the interrupt handler copies the MR information to the global RAM. This happens essentially in background as far as **mr_wait** is concerned.
- When the scanner comes back a second time with a completion status, the interrupt handler copies that status (plus the length of data and the data, for autoconfigure and link status) to your program's packet. Again, this is in background as far as **mr_wait** is concerned.
- When **mr_wait** senses in its loop that the request is complete, it returns control to your program. If the timeout interval runs out before the scanner comes back with a confirmation, **mr_wait** returns to your program anyway.

Data Structure (Packet)

QMR typedef

When you initiate an MR, you pass a packet to the library routines. The packet has a defined type of **QMR**.

This defined type is a structure that contains a field used only by the library routines, plus the following:

- **qmr_stat**

  unsigned integer confirmation status, initially equal to **SC_PENDING** and then set to the actual completion status after the scanner has finished with the MR.

- **qmr_len**

  unsigned integer length of data in bytes, which you fill in only when changing the scan list.

- **qmr_data**

  character array of 128 bytes, the data area.

Programmer Alert

Your program can get itself into trouble by misusing packets. Here are the pitfalls that relate to MRs:

- Improper reuse of pointers: If the **mr_wait** routine decides that the scanner has not responded in a reasonable time, your program is generally free to use the packet for a different MR. But suppose that your program had **g_timout** set too low so that **mr_wait** didn't wait long enough. (A scan list, the slowest request, can take up to 12 units, about 2/3 of a second.) Then the confirmation of the first request could come through and wipe out the information in the second request, which is waiting for a confirmation from the scanner. The library routines catch some but not all of these situations, and count up the ones they do catch in **g_pkt_err.** Generally, your program should not reuse a packet that contains a status of **SC_PENDING** unless absolutely sure that the scanner never responds to that command.

- Invalid pointers: Conforming to established C coding conventions, library routines that need access to user packets take pointers as their function arguments. There is no way for a called function to check whether your program has sent it a valid pointer. Therefore, you are completely responsible for sending valid pointers to the library routines. If the pointer arguments don't point to proper packets, your program can perform incorrectly or crash, possibly locking up the host computer.

Executing a Management Request

To start an MR, you store the required fields in the packet and then call the **mr_wait** function. **mr_wait** waits until the request is completed or has timed out and returns a completion status to your program.

Autoconfigure, setup, scan list, and fault dependent group can be executed only in program mode. Link status and set mode can be executed in any mode.

Timeout

The timeout period is the current value of global variable **g_timout** in 55 millisecond units. (The actual frequency is more nearly 1,193,180 / 64K Hz, about 18.2065 per second or 54.925 ms each.) If the scanner doesn't complete the MR within this time, **mr_wait** assumes that the scanner never completes the request.

The default timeout is 18 units, about 1 s. You can change the timeout interval by storing a new value in **g_timout.** However, be sure to allow a large enough interval. Worst-case times for autoconfigure and scan list are 272 ms and 704 ms respectively; for full explanations please see those sections. Link status, set operating mode, fault dependent group, and setup are always completed within one time unit, 55 ms.

The actual timeout interval can be as much as one unit less than the value you store in **g_timout.** The reason is that the **mr_wait** routine copies **g_timout** to the **g_decrem** counter, which counts down every 55 ms, and when **g_decrem** reaches zero the **mr_wait** function considers the request to have timed out. But if the clock tick happens to come right after **g_decrem** was set, the effective value of the timeout is almost a full 55 ms less that the nominal value. The bottom line? In deciding on a timeout (if you don't stick with the default value), always allow an extra unit above the value you calculated.

General Form

This section gives details for each of the six types of MR, but first we present a program skeleton, where command stands for the defined constant that names the desired command:

```
QMR mgmt;
unsigned confirm_stat;
. . .

mgmt.qmr_len = . . .     /* for scan list only */
mgmt.qmr_data[0] = . . . /* except autoconf & link */status
confirm_stat = mr_wait(command, &mgmt);
if ( !confirm_stat ) {
       /* successful completion */
}
else {
       /* unsuccessful completion */
}
mr_print(stderr, command, &mgmt); /* if display wanted */
```

The **mr_print** call shown in the program skeleton above displays the results of the MR on the screen. Such a call would probably be used only when operator intervention might be appropriate.

mr_wait

mr_wait returns a status code, which it also places in the **qmr_stat** field of the packet. For a complete list of status codes, please see Confirmation Status Codes later in this chapter. For now it's enough to know that **SC_OK** (0) means successful completion, **SC_PENDING** means the scanner didn't come back with a confirmation before timeout, and any other value is an error code returned by the scanner or the library routines.

You can code **if** tests based on the assumption that a zero status means success.

Example:

```
if ( mr_wait(. . .) )
       /* request failed */
```

or

```
if ( !mr_wait(. . .) )
       /* request succeeded */
```

If you prefer, you can call **mr_wait** without using its return value, since the **qmr_stat** field of the packet contains the same code:

```
mr_wait(. . ., &pkt);
if ( pkt.qmr_stat )
       /* request failed */
```

Set Operating Mode

To change the scanner's operating mode, you must set the first byte of the packet's **qmr_data** field to one of the three values **CM_RUN, CM_TEST, CM_PROGRAM**. Then call **mr_wait** with **C_SETMODE** as its first argument.

Calling sequence:

```
packet.qmr_data[0] = mode;
status = mr_wait(C_SETMODE, &packet);
```

where

- *packet* is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.
- *mode* is either **CM_PROGRAM**, **CM_TEST,** or **CM_RUN**.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.
- global variable **g_op_stat** reflects the new scanner operating mode if the request was successful.

Example: To change to run mode, execute the following code:

```
QMR mode_pkt;
        . . .
mode_pkt.qmr_data[0] = CM_RUN;
if ( mr_wait(C_SETMODE, &mode_pkt) ) {
    printf("can't execute set mode (%s)\n",
        xlat_conf(mode_pkt.qmr_stat));
    abort( );
}
```

For the **xlat_conf** function, which translates a confirmation status to English, see Confirmation Status Codes later in this chapter.

Setup

This MR lets you change the baud rate and connect or disconnect the line termination resistor. It also lets you put the scanner into "debugging mode," which disables the scanner watchdog. The scanner must be in program mode to execute a setup request; otherwise the scanner returns an error code.

Note: In the **SETUP_6008( )** function, **-1** indicates default parameters.

The symbolic name of the setup command is **C_SETUP.** The setup request takes three bytes of data:

- baud rate, 1 for 57.6 Kbaud, 2 for 115.2 Kbaud, or -1 to leave the present baud rate unchanged.
- resistor, 1 to connect, 0 to disconnect, or -1 for no change.
- debugging mode, 1 to disable the scanner watchdog and any other value to enable the watchdog. Debugging mode is discussed below.

WARNING: Debugging mode should be used only when someone is physically present to monitor the process. If the host program stops while scanner debugging mode is in effect, all output modules stay in last state. You should shut off the host computer's power switch immediately to terminate the process.

Calling sequence:

```
packet.qmr_data[0] = . . .   /* baud rate */
packet.qmr_data[1] = . . .   /* resistor */
packet.qmr_data[2] = . . .   /* debugging mode */
status = mr_wait(C_SETUP, &packet);
```

where

- *packet* is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.
- global variable **g_op_stat** reflects whether the scanner is in debugging mode (**SO_DEBUG** bit).

Example: If you want to switch to 115.2 Kbaud without changing the resistor setting, use this code:

```
QMR setup_pkt;
        . . .
setup_pkt.qmr_data[0] = 2;  /* baud multiplier */
setup_pkt.qmr_data[1] = -1; /* no change to resistor */
setup_pkt.qmr_data[2] = 0;  /* not in debug mode */
mr_wait(C_SETUP, &setup_pkt);
if ( setup_pkt.qmr_stat ) {
        printf("setup call failed (%d)\n",
setup_pkt.qmr_stat);
        abort( );
}
```

A note on debugging mode: Normally, the scanner expects the host to return the global RAM within 50 milliseconds after the scanner interrupts the host. (This is a comfortable margin: the host interrupt service routine takes about 0.1 to 2 ms, depending on the host CPU and how much work the interrupt routine has to do.)

After the 50 ms interval, the scanner watchdog kicks in. What that means is that the scanner decides that the host hardware or BIOS has died and therefore the scanner goes off the I/O link. In about another 50 ms the adapters all go inactive and the modules are in last state or reset according to the way you set their switches. Normally, this safety precaution is exactly what you want.

But if you're debugging your program you may want to single step through it, and each step would take longer than the scanner's 50-ms watchdog interval. This is the purpose of debugging mode: it turns the scanner watchdog off.

Make sure to turn debugging mode off (a setup request with any value other than 1 in the third byte) before your program exits. If your program ends while the scanner is in debugging mode, you have to cycle power before the scanner communicates with the host again. (In this case you should turn off host power anyway, as a safety measure, since otherwise all output modules are held in last state.)

Autoconfigure

In doing an autoconfigure, the scanner actually queries each possible adapter position to determine which addresses have adapters present.

To tell the scanner to do an autoconfigure, you simply issue an **mr_wait** function call with **C_AUTOCONF** as its first argument. The scanner must be in program mode to do an autoconfigure; otherwise the scanner returns an error status.

When the scanner does an autoconfigure, it forgets any fault dependent groups you may have set up. When doing an autoconfigure, the scanner also puts a new default scan list into effect. The default scan list is simply a list of all adapters that responded, in rack and group order. (In single slot addressing, a single adapter with more than eight slots looks like two adapters to the scanner.)

Calling sequence:

```
status = mr_wait(C_AUTOCONF, &packet);
```

where:

- *packet* is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.
- packet.qmr_data contains 32 words of configuration information, one for every possible adapter address, followed by 0 to 16 bytes of the current scan list; see discussion below.
- packet.qmr_len **c**ontains the length of data in bytes, which is 64 plus the length of the new default scan list. In other words, to obtain the length of the scan list you subtract 64 from packet.qmr_len.

  Before we give you further information on interpreting the data returned by an autoconfigure, you should know that we have provided a routine, **mr_print,** to turn all the information into English. For details, please see ”Print or Display Results” in this chapter.

The data returned by a successful autoconfigure can be divided into two parts:

- a fixed length part, 32 pairs of bytes. The first byte of each pair gives information about the size and type of the adapter, and the second byte gives fault information. For complete information, please see ”Autoconfigure and Link Status Information” in this chapter.
- a variable length part, 0 to 16 bytes long, containing the new default scan list. Each byte contains an adapter position in the form 4 x rack + group / 2. The length of the scan list is packet.qmr_len – 2 x 32**.**

The time required to complete an autoconfigure request depends on the baud rate and the number of adapters connected, as well as the size of each adapter. For simplicity, we consider worst case, where each adapter controls a full rack. In this case, the time to completion is 11 milliseconds per connected adapter (7 ms at 115.2 Kbaud) plus 6 ms for each of the 32 possible adapter positions where no adapter is connected. Doing the algebra, we have

```
T = 5 ms x adapters + 192  (57.6 Kbaud)
T = 1 ms x adapters + 192  (115.2 Kbaud)
```

Since no more than 16 adapters can be connected at once, worst-case time for an autoconfigure is 272 ms at 57.6 Kbaud, 208 ms at 115.2 Kbaud. (If 16 adapters are connected, they can’t all be full racks, so this is actually a longer time than true worst case.)

Link Status

A link status request returns the same information as an autoconfigure, but link status differs from autoconfigure in three ways:

- The scanner can execute a link status request while in any mode, not just program mode.
- The scanner doesn’t actually query possible adapters in doing a link status. Rather, the scanner copies its internal status tables to the global RAM.
- Fault dependent groups and the current scan list are not changed by a link status command.

To query the scanner about link status, simply issue an **mr_wait** function call with **C_LINKSTAT** as its first argument.

Calling sequence:

```
status = mr_wait(C_LINKSTAT, &packet);
```

where:

- *packet* is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.
- packet.qmr_data and packet.qmr_len contain exactly the same information as is returned by an autoconfigure, except that the scan list and fault dependent groups have not been disturbed. The scan list length may also be up to 64 bytes long rather than just 16. For complete information, please see ”Autoconfigure and Link Status Information” later in this chapter.

Scan List

You can use a scan list request to tell the scanner to give a larger share of its attention to some adapters at the expense of others. Though there are only 32 possible adapter addresses, and only 16 of those can be occupied at a time, the scan list can be up to 64 positions long.

The scan list and fault dependent group requests interact in one way: Every adapter that is part of a fault dependent group must also be part of the current scan list. If you try to violate this rule by specifying a new scan list, one that omits some adapters that are still in fault groups, the scanner returns an error code and leaves the old scan list in effect. To change the scan list in that way you must first issue a fault dependent group command that leaves the “orphan” adapters out of all fault groups.

The scan list request is the only MR that requires both data and length of data to be in the packet before you call **mr_wait.** The first argument to **mr_wait** is **C_SCANLIST**. The scanner must be in program mode to execute a scan list request; otherwise the scanner just returns an error code.

Calling sequence:

```
packet.qmr_len = . . .     /* length of scan list, 0-64 */
packet.qmr_data[0] = . . . /* first adapter address */
packet.qmr_data[1] = . . . /* second adapter address */
        . . .
packet.qmr_data[length-1] = . . . /* last adapter address */
status = mr_wait(C_SCANLIST, &packet);
```

where

- *packet* is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.
- packet.qmr_len, the length of the scan list, may be anything from 0 to 64 inclusive.
- packet.qmr_data contains the adapter addresses for the scan list, in the form 4 x rack + starting group / 2. A given adapter can occur more than once in the list, or an existing adapter may be omitted from the scan list.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.

  The time required to complete a scan list command is essentially the time to scan every adapter once: 11 milliseconds per scan list entry (7 ms/entry at 115.2 Kbaud). Since the scan list can be as long as 64 entries, the worst case time is 704 ms at 57.6 Kbaud, 448 ms at 115.2 Kbaud.

Example: Suppose you have two adapters connected, one controlling rack 1 (a full rack) and the other controlling the second half of rack 2. (The adapter addresses are 4 x 1 + 0 / 2 = 4 and 4 x 2 + 4 / 2 = 10.) Suppose you want to sample inputs from rack 2 every 5 seconds, but want the most current information possible from rack 1. You would enter a scan list request with adapter 2 occurring only once and adapter 1 occurring several times.

At first glance, you might try a scan list of 64 bytes, with 63 repeats of adapter 1 and one occurrence of adapter 2. (Since the scan list is processed repetitively, it doesn't matter where in the list the one occurrence of rack 2 is placed.) But if you want the most current information possible that may not be a good idea.

Recall that it takes up to 11 ms at 57.6 Kbaud, or 7 ms at 115.2 Kbaud, to scan each adapter in the scan list. If you're operating at 115.2 Kbaud with a scan list of 64 positions, your inputs are updated only every 64 x 7 = 448 ms. If you want information, say, every 100 ms, then you need a shorter scan list. 100 / 7 = 14.3, so you want a scan list only 14 or 15 positions long.

Here is code to create that scan list, using the **memset** function (provided with many compilers) to initialize a block of memory:

```
QMR scan_list;
        . . .
scan_list.qmr_len = 14;      /* length of scan list */
/* 13 occurrences of first adapter */
memset(scan_list.qmr_data, 4, 13);
scan_list.qmr_data[13] = 10; /* second adapter */
mr_wait(C_SCANLIST, scan_list);
if ( scan_list.qmr_stat )
       /* error code here */
```

Fault Dependant Group

In many applications, adapters are conceptually grouped together such that if any one of the adapters in a group is faulted, you want all the others to be faulted too. The fault dependent group (FDG) request implements this concept.

FDGs are numbered from 0 to 7. When you issue a FDG request, you specify which adapters should be put in FDGs and which FDGs they should be put in.

In the data array, you must fill the first 32 bytes, one for each possible adapter position. The subscripting is 4 x rack + group / 2. (In the subscript calculation, group is the adapter's starting group number within the rack, not the FDG number.) For each adapter position, if the adapter doesn't exist, or it exists but you don't want it to be in a fault group, put zero in the data byte. For each existing adapter that is in the current scan list and that you want in a fault group, put the fault group number ORed with **SF_IN_FGRP** in the data byte.

Note that an adapter is not allowed to be in an FDG unless it is also in the current scan list. If you want to increase the scan list and put the added adapters in fault groups, you must issue two commands in that order. If you try to issue a FDG request that puts unscanned adapters in fault groups, the scanner returns an error code and does not change the existing fault groups.

Once you've set up the data array, call **mr_wait** with a first argument of **C_FLT_GRP.** The scanner must be in program mode to execute a FDG request; otherwise the scanner returns an error code.

Calling sequence (example):

```
packet.qmr_data[...] = 0;  /* no fault group */
packet.qmr_data[...] = 1 | SF_IN_FGRP; /* fault group #1 */
        . . .
packet.qmr_data[...] = 0 | SF_IN_FGRP; /* fault group #0 */
status = mr_wait(C_FLT_GRP, &packet);
```

where

- *packe*t is a **QMR** type packet. Note that the argument to **mr_wait** is a pointer to the packet.
- packet.qmr_data contains the fault group numbers for the 32 possible adapter addresses, four per rack.

Returned values:

- status and packet.qmr_stat as explained under General Form, above.

Example: Suppose you have five adapters connected, four for the quarter racks in rack 6 and one for the first half of rack 0. If you want to link the four quarter-rack adapters in a fault dependent group, say group 1, and leave the half-rack adapter out of all FDGs, you can do it this way:

```
QMR fdg;
        . . .
memset(fdg.qmr_data, 0, MAXADAPT);
memset(fdg.qmr_data+6*4, 1|SF_IN_FGRP, 4);
if ( mr_wait(C_FLT_GRP,&fdg) )
       /* error code here */
```

Autoconfigure and Link Status Information

The autoconfigure and link status requests return a complicated data structure in the **qmr_data** field of the packet:

- The first part is fixed length and contains 32 words (byte pairs), one for each possible adapter position. Within each byte pair, the first byte contains configuration information, such as the size and type of the adapter, and the second byte contains fault status and fault dependent group information.
- The second part is variable length, being the current scan list, 0 to 64 bytes long. The length of the scan list is found by subtracting 64 from the value in the **qmr_len** field of the packet. Each byte contains an adapter address in the form 4 x rack + group / 2.

Here is some quick code to print the current scan list:

```
int len;
char *scan;
        . . .
len = packet.qmr_len - 2*MAXADAPT;
if ( !len )
       printf("scan list has no adapters\n");
else
       printf("current scan list (%d adapters):\n", len);
for ( scan=packet.qmr_data+2*MAXADAPT; len--; ++scan )
       printf("rack %d group %d\n", *scan>>2, (*scan&3)<<1);
```

Most of this section explains how to extract the configuration and fault information, working from the packet that was returned by a successful autoconfigure or link status request.

Configuration Information Byte

You can extract the configuration information byte for any adapter, based on the rack and starting group of the adapter. Either access an element of the **qmr_data** array, like this:

```
packet.qmr_data[ 8*rack + group ]
```

or use the **cfg_info** macro to do the same thing.

cfg_info

This macro obtains the configuration byte for a particular adapter from the **QMR**-type packet returned from an autoconfigure or link-status request.

Calling sequence:

```
status = cfg_info(&packet, rack, group);
```

Arguments:

- *packet:* a **QMR** structure, assumed to contain status **SC_OK** after an autoconfigure or link status request. Note that the actual argument is a pointer to the packet.
- *rack:* logical rack number, 0 to 7.
- *group:* starting group number, an even number from 0 to 6.

Returned values:

- an integer that can then be examined for the status bits described below (leading characters **SL_**). If you prefer, you can call the **xlat_cfg** function to convert the status bits to an English language string; see ”Print or Display Results” in this chapter.

Configuration Information Bit Fields

The fields listed in Table 7.A are defined in the low byte of the word of information about each adapter, which can be extracted by using the **cfg_info** function described above:

Table 7.A
Configuration Information Bit Field Descriptions

Bit Field	Hex Value	Description
SL_IN_SCAN	10 (hex)	true (1) if the adapter is in the current scan list. If this bit is zero, the other bits in the link status word are meaningless.
SL_EXISTS	08 (hex)	true (1) if an adapter is attached (or was attached earlier in the same execution of the program) and begins at this address. If this bit is zero, the bit fields listed below are meaningless.
SL_KNOWN	04 (hex)	true (1) if the adapter type, size, and address are valid. If this bit is zero, the bit fields listed below are meaningless.
SL_SIZE	03 (hex)	size of the adapter, measured in 1/4 rack units: values 0 to 3 represent 1/4 rack, 1/2 rack, 3/4 rack, and a full rack.
SL_NODE	40 (hex)	true (1) if this is a node adapter.
SL_FAST_NA	80 (hex)	true (1) if this is a fast node adapter.
SL_SNGL_PT	20 (hex)	true (1) if this is a single-point I/O adapter.

You can test for any of the above conditions by ANDing the information byte with the bit name.

Fault and Fault Dependent Group Information Byte

You can extract the fault information byte for any adapter, based on the rack and starting group of the adapter. Either access an element of the **qmr_data** array, like this:

```
packet.qmr_data[ 8*rack + group + 1 ];
```

or use the **flt_info** macro to do the same thing.

flt_info

Extracts fault information byte. This macro obtains the fault byte for a particular adapter from the **QMR** type packet returned from an autoconfigure or a link status request.

Calling sequence:

```
status = flt_info(&packet, rack, group);
```

Arguments:

- same as for **cfg_info** above.

Returned values:

- an integer that can then be examined for the status values described below (leading characters **SF_).** You may prefer to call the **xlat_flt** function to convert the status bits to an English language string.

  Before calling the **flt_info** function, your program should first examine the **SL_IN_SCAN** bit in the configuration byte for the same adapter, which can be obtained through **cfg_info** as shown in the sample code below. If **SL_IN_SCAN** is false (0), the fault information is meaningless.

Fault and Fault Dependent Group Bit Fields

The fields listed in Table 7.B are defined in the high byte of information about each adapter. The fault information byte can be extracted by using the **flt_info** function described above.

Table 7.B
Fault and Fault Dependent Group Bit Field Descriptions

Bit Field	Hex Value	Description
SF_ON_LINE	70 (hex)	true (1) if the adapter is on line, false (0) if faulted.
SF_IN_FGRP	08 (hex)	true (1) if the adapter is in a fault dependent group.
SF_GRP_NUM	07 (hex)	number of the fault group this adapter belongs to (meaningless if **SF_IN_FGRP** is zero).
SF_GRP_FLT	80 (hex)	true (1) if this adapter has been instructed to go into fault mode because a member of its fault group is faulted.

You can extract the fault dependent group number (0-7) by ANDing the fault information byte with the constant **SF_GRP_NUM,** provided that the **SF_IN_FGRP** bit is set.

Coding Examples

Here's some sample code to extract the fault dependent group number:

```
status = flt_info(&pkt, rack, group);
if ( status & SF_IN_FGRP )
       fdg_number = status & SF_GRP_NUM;
else
       fdg_number = -1; /* no fault dep group */
```

This is a partial sample of coding for status of the adapter starting at rack 3, module group 4.

```
QMR  config_pkt;
int  status, fault;
        . . .
if ( mr_wait(C_LINKSTAT, &config_pkt) != SC_OK ) {
        /*error in MR execution*/
}
else {
        status = cfg_info(&config_pkt, 3, 4);
        fault  = flt_info(&config_pkt, 3, 4);
        if ( status & SL_IN_SCAN ) {
                /*the adapter is in the scan list*/
        printf("adapter size: %d/4
rack\n",1+(status&SL_SIZE)):
        if ( ! (fault & SF_ON_LINE) )
                printf("adapter is faulted\n");
        if ( fault & SF_IN_FGRP )
                printf("in fault group %d\n",
fault&SF_GRP_NUM);
        }
}
```

Recall that the other bits in a configuration byte have no meaning if the **SL_IN_SCAN** bit isn't set. There are some additional dependencies, too: you are encouraged to make use of the **xlat_cfg** and **xlat_flt** routines described in later in this chapter in "Print or Display Results".

Confirmation Status Codes

This section lists the confirmation status codes that the scanner may return when processing an MR. Before the list of codes, we present a routine that turns a numeric code into an English message.

xlat_conf

Translates a confirmation status. This function converts a confirmation status value to English.

Calling sequence:

```
explan = xlat_conf(status);
```

Arguments:

- *status:* a confirmation status returned in the **qbt_stat** or **qmr_stat** field of a packet after the packet was passed to a library routine.

Returned values:

- a character pointer that points to a string suitable for printing. The string length varies depending on the message, but do not exceed 47 characters (46 plus the terminating zero byte).

Table 7.C lists the confirmation status codes for a management request.

Table 7.C
Confirmation Status Code Descriptions

Status Code	Hex Value	Description
SC_PENDING	FF (hex)	not yet transmitted to the scanner, or transmitted to the scanner but not yet confirmed back to the host.
SC_OK	00 (hex)	completed successfully.
SC_BAD_CONFIG	16 (hex)	the request attempted to specify a scan list that omits some adapters that are in fault dependent groups, or to specify a set of fault dependent groups including some adapters that aren't in the current scan list.
SC_BAD_LEN	15 (hex)	invalid length for a **C_SCANLIST** command.
SC_BAD_PARAM	11 (hex)	invalid parameters to a valid command.
SC_BAD_REQ	10 (hex)	invalid command.
SC_PROG_MODE	13 (hex)	invalid attempt to issue an autoconfigure or a setup, scan list, or fault dependent group command while not in program mode.
SC_REQ_PEND	12 (hex)	invalid attempt to enter a management request while another one was pending. (This should never happen because the **mr_wait** routine doesn't return to your program until the pending request is finished.)
SC_NOT_OK	01 (hex)	some other error, most likely invalid arguments passed from the user program to the library queue routines.

Print or Display Results

This section tells you about three functions that are useful in formatting the results of an MR for display.

One, **mr_print,** formats the complete results of any MR, including both the fixed and variable parts of an autoconfigure or link status. The other two functions, **xlat_cfg** and **xlat_flt,** translate just one byte of data from the autoconfigure or link status fixed portion.

Note that **xlat_cfg** and **xlat_flt** each have an internal string buffer and return a pointer to that buffer. Calling one of these routines destroys the previous contents of the buffer for that routine, but leaves the other buffer unaffected. This means that you must use the string returned by either of these routines before you call the same routine again.

mr_print

Formats an MR queue entry for display. This function translates the command and status to English for writing to screen or file. If the MR was for link status or autoconfigure, **mr_print** also displays expanded information on all adapters.

Calling sequence:

```
mr_print(fileptr, command, &qmrptr);
```

Arguments:

- *fileptr:* stdout or stderr for screen output, or a pointer to a user file opened with fopen.
- *command:* an integer, the management request. This is one of the six symbolic constants **C_AUTOCONF, C_FLT_GRP, C_LINKSTAT, C_SCANLIST, C _SET_MODE, C_SETUP.** (**mr_print** needs to know which command you issued because the interpretation of the data is different for different commands.)
- *qmrptr:* the **QMR-**type packet that was passed to **mr_wait.** Note that the function argument is a pointer to the packet.

Returned values:

- none.

  mr_print displays as much information as possible in English, rather than in numeric codes. For instance, if the command was **C_AUTOCONF** or **C_LINKSTAT**, **mr_print** displays a line of information about each adapter that is in the scan list, followed by a display of the scan list showing the order in which adapters are scanned. For these commands plus **C_SCANLIST**, **mr_print** separates adapter addresses into the form rack/group.

xlat_cfg

Translate a configuration byte to English.

Calling sequence:

```
explan = xlat_cfg(config);
```

Arguments:

- *config:* a byte from the array returned by an autoconfigure or link status call, possibly extracted by the **cfg_info** routine.

Returned values:

- a character pointer whose object is a string of 23 characters (22 plus the terminating zero byte) suitable for printing. This pointer points to an internal buffer whose contents are destroyed by subsequent calls to **xlat_cfg.**

  If the **SL_IN_SCAN** bit is zero, all other fields are meaningless and the function returns a string containing the message “not in scan list”.

  If the **SL_IN_SCAN** bit is set but the **SL_EXISTS** it is not, all other fields are meaningless and the function returns “never responded”.

  If the **SL_IN_SCAN** and **SL_EXISTS** bits are both set but the **SL_KNOWN** bit is not, all other fields are meaningless and the function returns “responding improperly”. This means that the address, size, or length information returned by the adapter appears invalid.

  If the **SL_IN_SCAN**, **SL_EXISTS**, and **SL_KNOWN** bits are all set, the other fields are meaningful and the function attempts to interpret them. The first part of the string contains one of the messages “1/4_rack”, “half_rack”, “3/4_rack”, or “full_rack” right justified in a nine character field. Then if one of the adapter type bits is set one of the three messages “node_adapter”, “fast_node_ad”, and “single_pt_ad” appears, separated by a space from the size field.

  No tabs or newlines are ever included in the returned string.

xlat_flt

Translate a fault information byte to English. Note that this function returns correct information only if the **SL_IN_SCAN** bit is set in the configuration byte for the same adapter.

Calling sequence:

```
explan = xlat_flt(fault);
```

Arguments:

- *fault:* a byte from the array returned by an autoconfigure or link status call, possibly extracted by the **flt_info** routine.

Returned values:

- a character pointer whose object is a string of 28 characters (27 plus the terminating zero byte) suitable for printing. This pointer points to an internal buffer whose contents are destroyed by subsequent calls to **xlat_flt.**

  If the **SF_ON_LINE** field is nonzero, the first seven characters of the returned string contain “on_line”; otherwise the string begins with “faulted”. A space follows either message.

  If the **SF_IN_FGRP** bit is set, the **SF_GRP_NUM** field is extracted and the next ten characters of the string contain “flt_grp_#n” where n is the extracted group number; otherwise the next ten characters contain “no_flt_grp”.

  If the **SF_GRP_FLT** bit is set, the final nine characters contain a space and “grp_fltd”; otherwise they are blank.

  No tabs or newlines are ever included in the returned string.

Chapter 8

Block Transfer

Chapter Objectives

This chapter explains how to transfer data between intelligent I/O modules (block transfer modules) and your program's data area. After reading this chapter you should be able to:

- read a block of data from an intelligent I/O module
- write a block of data to an intelligent I/O module
- calculate how long it takes any given block transfer to finish
- poll for completion of the block transfer
- use a library routine to display the results on screen or printer or format them to a file.
- perform block transfers to a PLC5 in adapter mode
- perform block transfers to a 1771–DCM.

To make this chapter shorter and easier to read, we use the abbreviation BT for block transfer.

Overview

Here is a summary of the actions involved in completing a BT:

- Your program puts the BT length into a packet of specified structure. For a write BT, your program also puts the data into the packet.
- Your program calls **bt_que** or another library routine.
- The library routine adds your BT to its queue and interrupts the scanner to alert it that the host has a request. The library routine writes a status of "not complete" in your packet and returns control to your program without waiting for a response from the scanner.
- A short time later, the scanner responds to the interrupt and the host's interrupt handler puts the BT information into the global RAM. Although this action interrupts your program, you can think of it as something that takes place in background.

- Meanwhile, your program is periodically polling for completion of the BT, either by examining the packet directly or by using the **bt_done** macro.
- When the BT is complete, or if it is not finished within 4 seconds after it was queued, the scanner interrupts the host with a confirmation status and the length of data actually transferred. For a read BT, if the BT was successful the scanner also passes the data that it read.
- The interrupt handler writes the confirmation status, length of data, and (for a read BT) data to your program's packet. Again, you can think of this as taking place in background.
- The next time your program polls for completion, it finds that the BT is finished and can examine the status to determine whether it succeeded. For a successful read BT, your program can then make use of the data.

In the following sections we'll be taking a closer look at these steps.

QBT Data Structure (Packet)

When you initiate a BT, you pass a packet to the library routines. The packet is a defined type of **QBT.** You should declare it **static** unless you have good reason not to: see the "Programmer Alert" below.

The **QBT** defined type is a structure that includes the following fields, all of type unsigned integer, in addition to a field of concern only to the library routines:

qbt_stat

confirmation status; see "Confirmation Status Codes" later in this chapter for a complete list. The library routines initialize this to **SC_PENDING,** and change it to the actual confirmation status when a reply is received from the scanner. Your program can determine whether the BT is done by testing this field for equality to **SC_PENDING** or by calling the macro **bt_done**. See "Polling for Completion" later in this chapter.

qbt_len

length of data in words, up to 64. A value of 0 (zero) is permitted and tells the module to decide how many words to transfer (never more than 64). The number of words actually transferred is always left in this field after the BT has finished or timed out; in case of timeout or other error, this field is set to zero. After completion, the value is from 0 to 64.

qbt_data

data area, an array of 64 words. For a write BT, you must place the data in this area before calling a library routine to queue the BT; and if the length of data is zero you must be sure to have enough data for the module.

Programmer Alert

Your program can get itself into trouble by misusing packets. Here are the pitfalls:

- **Improper declaration of packets:** It would be natural for a function to declare a packet as follows:

  ```
  QBT  packet;          /* possibly unsafe */
  ```

  But this declares the packet on the stack, which may not produce the desired results. Suppose your program has a declaration like the above in a function, say **x**, and calls a library routine to queue a BT. If **x** then returns to its calling function, say **c**, then **x** (which contains the packet declaration) is no longer active by the time the scanner comes back with the confirmation. The interrupt handler still has a record of the absolute core location of your packet, but that core location is now in use by some other function's stack. The library routines can detect some of these situations, but not all. The running count of occurrences detected is stored in global variable **g_pkt_err.**

  You have two defenses against this problem. The way requiring less thought, and providing absolute safety, is simply to declare all **QBT** packets **static.** This ensures that the physical data locations are not used by any other variables during execution, but may increase program size unnecessarily. The other technique is to take note of the structure of your program and locate packet declarations so that each packet is declared in a function that definitely does not return to its caller before the scanner has returned a completion status.

- **Improper reuse of pointers:** A second potential problem is closely related to the preceding one. If your program decides that the scanner has not responded in a reasonable time, the program is generally free to use the packet for a different BT. But suppose that your program simply didn't wait long enough. Then the confirmation of the first request could come through and wipe out the information in the second request, which is waiting for a confirmation from the scanner. Again, the library routines catch some but not all of these situations, and count up the ones they do catch in **g_pkt_err.** Generally, your program should not reuse a packet that contains a status of **SC_PENDING** unless absolutely sure that the scanner is not responding to that command.

- **Invalid pointers:** Conforming to established C coding conventions, library routines that need access to user packets take pointers as their function arguments. There is no way for a called function to check whether your program has sent it a valid pointer. Therefore, the programmer is solely responsible for sending valid pointers to the library routines. If the pointer arguments don't point to proper packets, the program performs incorrectly or crashes, possibly locking up the host computer.

Queueing a Block Transfer

To start a BT, you store the needed fields (length of data, plus the actual data for a write BT) in the packet and then call the **bt_que** routine. If you prefer, you can use **bt_read** and **bt_write.** Those macros compile into calls on **bt_que** but let you omit one function argument from your program.

Once the request has been queued, your program must check periodically to see whether the request has finished; see "Polling for Completion" in this chapter.

bt_que

Use this routine to initiate a BT. This routine adds a BT to the pending list and interrupts the scanner to pass it the command.

Calling sequence:

```
status = bt_que(command, address, &packet);
```

Arguments:

- *command:* an integer, either **C_BT_READ** or **C_BT_WRITE**.
- *address:* an integer, the module or slot address (0–127), formed by multiplying the rack address (0–7) by 16 and adding the slot address (0–15). Equivalent arithmetic would be rack times 16, plus group times 2, plus 1 for right–hand slot or 0 for left–hand slots.
- *packet:* a pointer to a **QBT** structure where you have filled in the length of data (and the data, for a write BT).

Returned values:

- error status, **OK** if the request was successfully entered in the queue or **NOT_OK** if the queue was full or the request was invalid. This is the status of queuing the request, not of executing it. Your program can determine the latter status by examining the **qbt_stat** field in the packet.

Example:

```
static QBT btr;
#define CHANNEL_IN (16*2 + 3) /* slot 3, rack 2 */
        . . .
btr.qbt_len = 15;
if ( bt_que(C_BT_READ, CHANNEL_IN, &btr) )
        printf("can't queue the read BT\n");
```

---

bt_read, bt_write

Use this routine to initiate a read or write BT. These macros compile as references to **bt_que,** but save typing one argument.

Calling sequence:

```
status = bt_read(address, &packet);
```

or

```
status = bt_write(address, &packet);
```

Arguments:

- same as the last two of **bt_que** above.

Returned values:

- same as for **bt_que** above.

Time to Completion

The factors affecting the time to empty the scanner's BT queue are as follows. They are roughly in descending order of importance.

- The number of BTs queued to the same adapter. (Note: A single adapter, containing more than eight slots and using single slot addressing, appears to the scanner as two distinct adapters. In this case, the lower eight slots belong to the first apparent adapter.)
- The number of BTs queued to the same module.
- The number of times an adapter appears in the scanner's scan list.
- The length of the scanner's scan list.
- The number of words of BT data to be exchanged.
- The baud rate.

Timing Formula

In the following formula, we assume that the module is ready to perform a transfer when asked, as is frequently true. (If a module is not ready to perform a BT when asked, then the time for it to get ready must be added to the total time.

T = (Effective Number of Scans) x (Scan List Length) x (Time per Scan) + (Number of BTs) x (Time per BT) + ((Number of Words) x (Time per Word))

where T is the time it takes to complete all block transfers that are queued, given the constraints of the formula.

Effective Number of Scans: If each adapter is in the scanner's scan list only once, and no module has more than one BT queued to it, then the effective number of scans is the largest number of BTs queued to any one adapter, plus one. For complete details, see the "Number of Scans" section below.

Scan List Length: The number of adapters in the scan list.

Time per Scan: The time required to scan an adapter depends on the baud rate. At 57.6 Kbaud the time is 11 milliseconds. At 115.2 Kbaud the time is 7 ms.

Number of BTs: The total number of BTs in the scanner's queue.

Time per BT: At 57.6 Kbaud or 115.2 Kbaud the time is 5.0 ms.

Number of Words: The total number of words of BT data to be exchanged. This includes all BTs in the queue.

Time per Word: At 57.6 Kbaud this time is 0.3 ms. At 115.2 Kbaud this time is 0.2 ms.

Number of Scans

The total number of scans needed to empty the scanner's BT queue is equal to the largest (effective) number of scans needed to service all of the BTs queued to any single adapter. In other words, determine the effective number of scans each individual adapter needs, then use the largest one.

The following is a procedure to determine the number of scans any individual adapter needs. Remember that a single adapter, containing more than eight slots and using single slot addressing, appears to the scanner as two distinct adapters.

- If none of the BTs are queued to any given module more than once, then the number of scans is equal to the total number of BTs plus one. For example, if four BTs are queued to four different modules, then the number of scans needed to service all of the BTs queued to that adapter is five. (4 BTs + 1 = 5 scans)

- If more than one BT is queued to a given module, then two scans per BT must be used. If more than one module has multiple queued BTs, then the number of scans needed is equal to the largest number for any module. For example, an adapter has five BTs queued to it, two of them going to one module and three to another. The number of scans to service that adapter is six. (3 BTs x 2 scans per BT = 6 scans)

At this point, you know the number of scans needed to service each individual adapter. However, for the calculation of the time to empty the scanner's queue, the effective number of scans is required. The effective number of scans is equal to the number of scans divided by the number of times the adapter appears in the scanner's scan list. For example, if the number of scans to service an adapter's BTs is 11, and the adapter appears in the scan list four times, then the effective number of scans to service that adapter is 2.75. (11 scans / 4 entries = 2.75 effective scans).

The effective number of scans to use to determine the total time to empty the scanner's queue is the largest effective number of scans for any individual adapter.

Polling for Completion

Once your program has queued a BT, you must check periodically to see whether the scanner has finished it. (Why? The scanner interrupts the host to pass back completion status, but this goes on in background as far as your program is concerned. So the status in the packet seems to change while your program is executing.)

There are two ways to poll for completion: by examining the packet and by using the **bt_done** macro.

Packet Check

Your program can periodically check the **qbt_stat** field of your packet. As long as the field is equal to **SC_PENDING,** the scanner still has the BT in its queue. As soon as the packet status changes to any other value, it is the actual completion status passed by the scanner.

A list of status values is in ”Confirmation Status Codes” in this chapter, but for a first approximation all that matters is whether the status is **SC_OK** (successful completion) or anything else.

Ordinarily your program would do other things while waiting for the BT to finish. You could start up other BTs, do discrete I/O, issue management requests, or a combination of these. But at some point in your program scan you need to test for completion of this BT:

```
if ( pkt.qbt_stat != SC_PENDING ) {
        if ( pkt.qbt_stat == SC_OK ) {
                /* successful completion */
        }
        else {
        /* BT failed; pkt.qbt_stat contains reason */
        }
}
```

bt_done

Your program could monitor the status of a BT directly by an **if** test as shown above, but it may be clearer to use the **bt_done** macro, like this:

```
if ( bt_done(&btrpkt) ) . . .
```

bt_done is a macro that compiles to the **if** test given earlier. The only difference is that **bt_done** may make your program read a little more clearly.

Calling sequence:

```
status = bt_done(&packet);
```

Arguments:

- *packet:* a pointer to a packet that has previously been the argument of a **bt_que, bt_read,** or **bt_write** call.

Returned values:

- false (0) if the BT is still pending, true (nonzero) if it has finished successfully or unsuccessfully.

  Once **bt_done** returns a value of true, you can interrogate the status as we did above.

  bt_done is not limited to the (rare) case where your program doesn't want to do anything else until the BT has finished, but the logic of that case is particularly clear when we use **bt_done**:

```
static QBT btr;
#define CHANNEL_IN (16*2 + 3) /* slot 3, rack 2 */
        . . .
btr.qbt_len = 15;
if ( bt_que(C_BT_READ, CHANNEL_IN, &btr) )
       printf("can't queue the read BT\n");
else
       while ( !bt_done(&btr) )
              ; /* empty wait loop */
if ( pkt.qbt_stat == SC_OK ) {
       /* successful completion */
       }
       else {
              /* BT failed; pkt.qbt_stat contains reason */
}
```

Confirmation Status Codes

This section lists the confirmation status codes that the scanner may return when processing a BT. Some of them are duplicates of those listed in chapter 7, Scanner Management.

Please note that the **xlat_con** routine (described in chapter 7, ”Scanner Management”) can also be used to translate BT confirmation status codes.

Table 8.A
Confirmation Status Codes

Status Code	Hex Value	Description
SC_PENDING	FF (hex)	not yet transmitted to the scanner, or transmitted to the scanner but not yet confirmed back to the host
SC_OK	00 (hex)	completed successfully
SC_BAD_PARAM	11 (hex)	invalid parameters to a valid command
SC_BAD_REQ	10 (hex)	invalid command (can occur only if the first argument to **bt_que** is neither **C_BT_READ** nor **C_BT_WRITE**
SC_BT_CHKSUM	28 (hex)	checksum error in performing the BT
SC_BT_DIR	26 (hex)	user program requested a write but the module requested a read, or vice versa
SC_BTQ_LEN	27 (hex)	application length didn’t match module–requested length
SC_BTQ_FULL	14 (hex)	the scanner’s BT queue is full (should never happen because the library routines should refuse the request)
SC_BT_TIME	23 (hex)	BT timed out (was not completed within 4 seconds after the scanner received the request from the host)
SC_NOT_OK	01 (hex)	some other error, most likely invalid arguments passed from the user program to the library routines

Print or Display Results

A routine is available to display the results of a BT on a screen or a printer or write formatted results to an ASCII file.

bt_print

format a BT queue entry for display. This function translates the command, address (rack, group, slot), and status to English for writing to screen or file, and formats the data as hex words, 8 per line.

Calling sequence:

```
bt_print(fileptr, command, address, &qbtptr);
```

Arguments:

- *fileptr:* stdout or stderr for screen output, or a pointer to a user file opened with fopen.
- *command:* an integer, either **C_BT_READ** or **C_BT_WRITE**.
- *address:* the module address that was passed to the original queueing function.
- *qbtptr:* a pointer to your **QBT** type packet.

Returned values:

- none.

Example: This code tests a BT for completion and prints the results when the BT has finished:

```
#define OUT_VOLTS (16*4) /* rack 4 slot 0 */
static QBT btw;
        . . .
bt_write(OUT_VOLTS, &btw);
        . . .
if ( bt_done(&btw) )
       bt_print(stdprt, C_BT_WRITE, OUT_VOLTS, &btw);
```

Unsolicited Block Transfer

The scanner places a module control byte (MCB) in the output image table of the location of the BT modules discrete address when starting a read or write BT.

Your program should never write to the output image bytes that correspond to intelligent I/O modules; but if your program does, and happens to write a valid MCB, the intelligent I/O module thinks the scanner is trying to do a BT and responds accordingly. But the scanner doesn't know anything about a BT, so it tells the module "no thanks!" and sets the **SO_OIT_ERR** bit in the operating status word. This indicates that a module tried to start an unsolicited BT, one that the scanner itself knew nothing about.

This operating status bit stays set until your program resets it. Your program should check once per program scan for this operating bit and then should reset it:

```
if ( g_op_stat & SO_OIT_ERR ) {
        /* take appropriate action for your application, and
... */
                g_op_stat &= ~SO_OIT_ERR; /* clear the bit */
}
```

In addition, the library routines keep a count in global variable **g_oit_err** of notices received from the scanner about unsolicited BTs.

Block Transfer to PLC5's in Adapter Mode

A common configuration of PC based control systems using a scanner, is for the scanner to communicate with PLC5 family processors set up for adapter mode operation. In this configuration, the scanner is communicating with the PLC5 over the remote I/O link and the PLC5 emulates a 1771–ASB adapter module. The scanner has no way of knowing it's transferring data directly with a PLC, it thinks it is communicating with an adapter module.

The PLC5, while in adapter mode, has only local I/O. The PLC5's remote I/O network is dedicated to the scanner. Likewise, the physical port of the PLC5 used for the remote I/O link, is dedicated to the scanner, because this is where the scanner's I/O link is physically connected. The baud rate of the I/O link must be 57.6 KBaud, because the PLC5 communicates only at 57.6 KBaud.

Because the PLC5 does not have remote I/O of its own, rack 3 of the PLC5's I/O image table is reserved for communications with the scanner. Rack 3 normally would have been used by the PLC5 as a remote rack on its remote I/O network. But rack 3 now becomes the bridge between the PCbus I/O scanner and the PLC5.

The PLC5 has switches on it that determine the rack number it will emulate while in adapter mode. The rack number can be any number between 0–7. This will be the rack address the scanner uses to transfer data to the PLC5. When the scanner does an autoconfigure, this will be the rack number that is put into the scanner's scan list.

Discrete Transfer

When both the scanner and the PLC5 are in run mode, 8 input words and 8 output words will automatically be exchanged between the scanner's image tables and rack 3 of the PLC5. The 8 words of the scanner's input image will be updated with the 8 words from the PLC5's output image table from rack 3. Likewise, the data from the scanner's output image table associated with the PLC5's rack number will be transferred to the PLC5's rack 3 input image table. This happens automatically when the scanner is in run mode, just like it transfers data to other full 16–slot I/O racks. There is nothing that has to be programmed in ladder logic of the PLC5 to make this happen. If the PLC5 wants the data from the scanner to go to its own local I/O, the PLC5 will have to have a ladder logic instruction (file copy) to get the data from rack 3 to rack 0.

Note: Of the 8 words that are transferred back and forth between the scanner and PLC5, the first word, both from the input image and output image table, is reserved for rack status information and block transfer status. No data should be placed there by an application program.

Because the first word is automatically used for status, there are 7 words, both input and output, that can be used to move data between the scanner and the PLC5. If your application requires more than 7 words to be transferred between the scanner and the PLC5, then the block transfer protocol is used to transfer up to 64 words of data.

Block Transfer

For the scanner to issue a block transfer to a PLC5 in adapter mode, it must pretend it is sending data to an intelligent I/O module located in slot 0 of the rack number the PLC is emulating. Remember, the PLC5 is not emulating Rack 3, it is emulating the rack number (0–7) that was set with switches on the PLC5. When the scanner issues the block transfer, the Length of Data Block entry **must be 0**, because the PLC5 must decide how many words will be transferred.

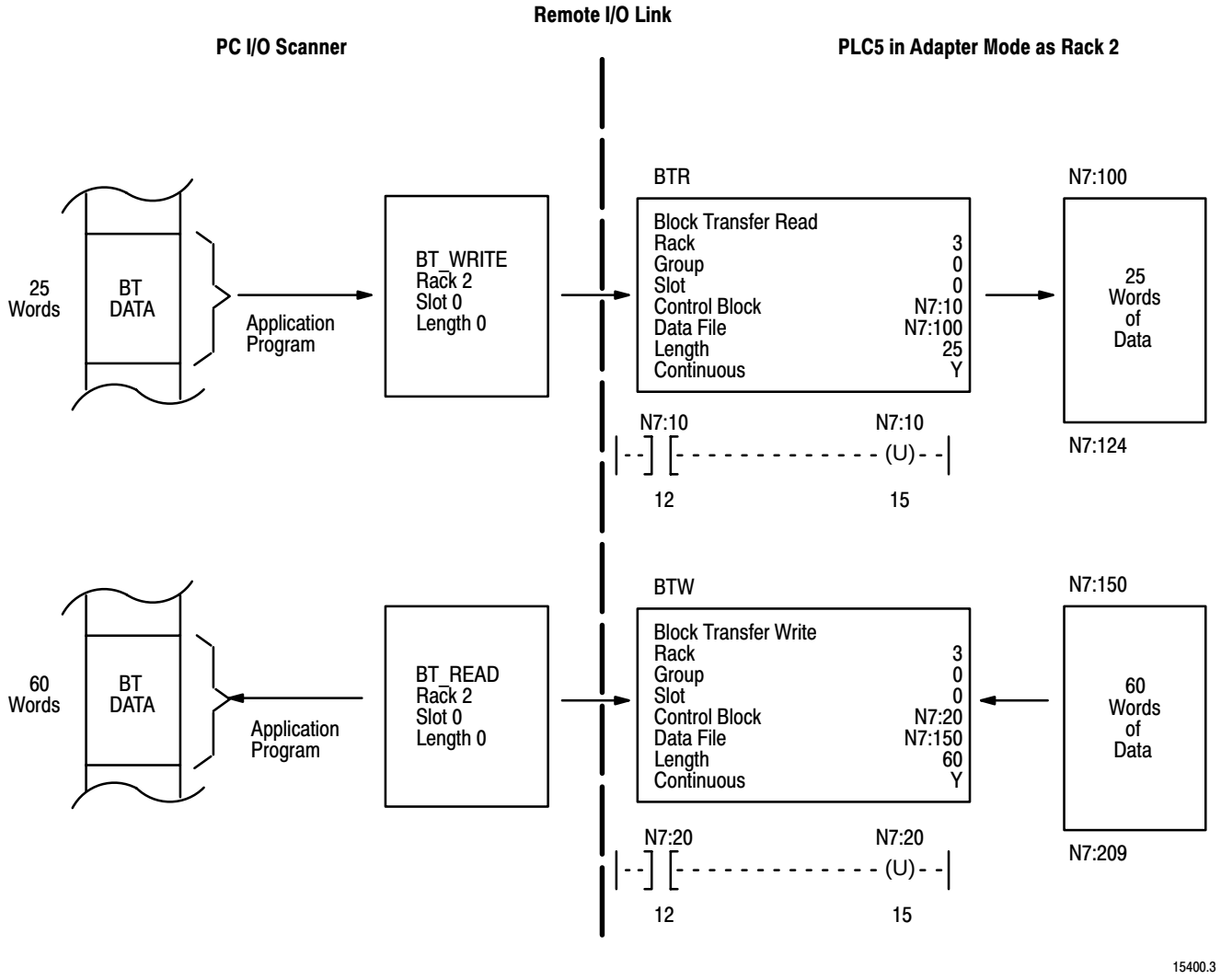
In order for the block transfer to happen, the PLC5 must have a block transfer ready to be transferred in the opposite direction so it can satisfy the request of the scanner. The PLC5 must constantly be trying to send a block transfer, even though most of the time it will fail, since the scanner has not asked for a block transfer. Because the PLC5 will never know when a block transfer request is coming, the block transfer ladder logic instruction should be set for continuous. This will provide a constant block transfer request to the scanner, so that when the scanner initiates a request, there will be one waiting for it.

Note: Whenever a block transfer instruction in a PLC5 is set for "continuous", there must be a separate line of ladder logic that will reset the enable bit in case the block transfer fails due to communication errors or protocol errors.

The parameters for the ladder logic block transfer instructions will be set so that the PLC5 thinks it is trying to do a block transfer to an intelligent I/O module in rack 3, module group 0, and slot 0. The length parameter value will be the number of 16–bit words that will be transferred to the scanner. The length value should not be 0, because the scanner is letting the PLC5 decide how many words are to be transferred.

As described earlier, the instruction should be continuous, along with a separate line that examines the block transfer fault bit from the block transfer control word and unlatches the enable bit if it ever does fault. A good idea would be to count the fault bits and if they ever get excessive, alert an operator that there is a problem.

Figure 8.1
Application Program Examples



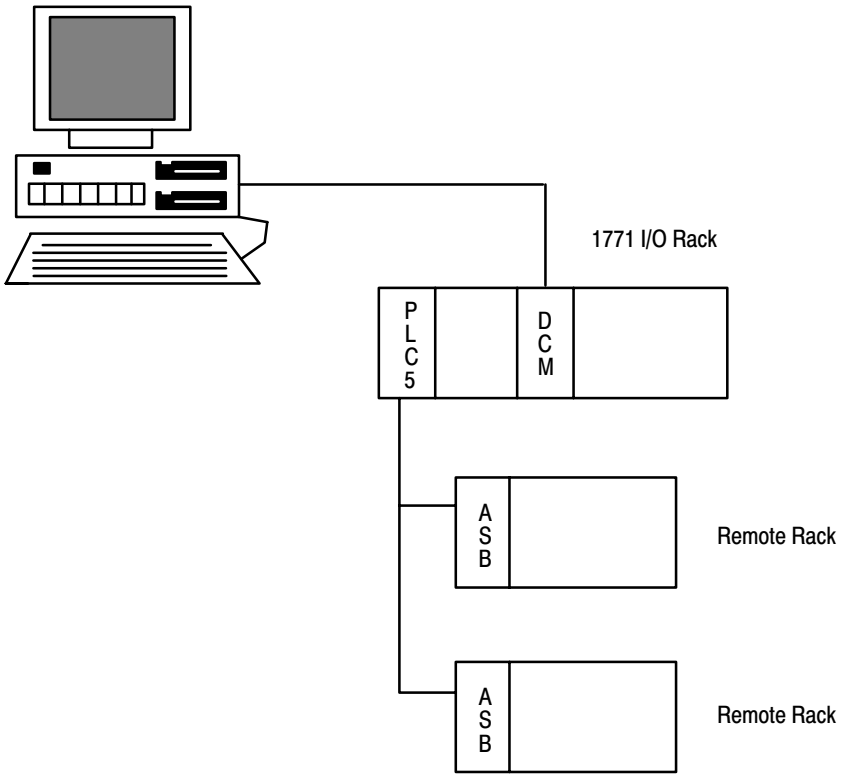
Block Transfer to a 1771–DCM

The 1771–DCM (Direct Communication Module) is a module that plugs into any existing 1771 chassis that has a free empty slot. It allows data to be collected by the PC I/O scanner from an existing I/O chassis. The DCM appears to the scanner as a rack of I/O, exactly the same as a PLC5 in adapter mode. The scanner can scan the DCM and automatically get eight words of discrete input data and provide eight words of output data, or the scanner can block transfer data to the DCM. The DCM can communicate at either 57.6K Baud or 115.2K Baud.

The local PLC, in the same rack as a DCM, block transfers data that needs to be sent to the scanner through the DCM. Once the DCM has gotten the data from the local PLC, it is ready to do a block transfer with the scanner. The block transfer programming techniques are exactly the same as communicating with a PLC5 in adapter mode.

Figure 8.2 shows a typical configuration using a DCM with your scanner.

Figure 8.2
Example Configuration of Scanner and 1771-DCM



Chapter 9

General Support Features

Chapter Objectives

This chapter explains how to use the library functions not discussed in earlier chapters. After reading this chapter, you should be able to:

- write timing loops
- date and time stamp your program output
- use a supplied library routine to translate a numeric scanner command to English.

Timing Loops

The interrupt handler that we supply maintains two counters for the use of your program: one unsigned counter that counts up every 55 milliseconds and one signed counter that counts down every 55 ms. (The actual interval is more nearly 1,193,180 / 64K Hz, about 18.2065 ticks a second.)

The time base is determined by host hardware and cannot be changed by user programming. If 55 ms intervals are too large for your timing, your only recourse is to program the timer chip. Such programming is beyond the scope of this manual, but you should be able to find the necessary information in the hardware technical reference manual for your host computer.

If your application needs more than two timers, you can also use the system time function described in the next section. Remember to take account of midnight in your coding.

The two timers described in this section work only after a call to **setup_6008** or **start_6008** and before a call to **stop_6008.**

g_accum

is an unsigned integer timer accumulator for the exclusive use of your program. Since **g_accum** has a capacity of 65,535 ticks, it flips back to zero in about an hour if not reset by your program during that time.

Your program can write a loop using the accumulator timer by setting it to zero, then repeatedly testing for some desired value. For instance, to wait for approximately half a second the following code would suffice:

```
for ( g_accum = 0;  g_accum < 9;   )
        ;     /* null wait loop: 495 ms max */
```

This technique, while easy, is not terribly accurate. Why? When you set **g_accum** you are not necessarily synchronized with a clock tick. If you happen to set **g_accum** just after a clock tick, it will be almost 55 ms until the next tick and your program will spend almost 495 ms in the loop. But if you happen to set **g_accum** just before a tick, the time spent in the loop will be almost a full tick short. In general, you should code loops that wait for external events to allow one more tick than necessary.

g_decrem

decrement timer (negative timer accumulator), an integer whose value decreases once for every clock tick. The time base is the same as for **g_accum,** and therefore **g_decrem** flips from negative to positive about once an hour.

This counter is intended primarily for use by your program, but is also used by the driver routines **start_6008, setup_6008, mr_wait,** and **update.** Therefore you should not use **g_decrem** to control any timing loop that contains a call to any of those routines. (In any case, **start_6008** and **setup_6008** should not be in a loop.)

Timer decrement loops start with a certain value and wait until **g_decrem** reaches zero. A pure wait loop can test for **g_decrem** nonzero, but a loop that does something and is also terminated by time should test **g_decrem** not positive in case one pass through the loop takes more than one clock tick.

Here's a sample of a pure one second wait loop, using a **while loop** rather than a **for loop** for variety:

```
g_decrem = 19; /* 990 to 1045 ms */
while ( g_decrem )
;     /* null loop for waiting */
```

Please read the explanation of **g_accum** above for the 55 ms uncertainty in timing.

If your timing loop actually does something, you might write it this way:

```
for ( g_decrem=19;  g_decrem>0 && ...;  ) {
       /* loop action here */
}
```

As shown above, you can end the loop when it times out or when some other condition occurs.

Date and Time Stamp

In this section we provide three routines to access the system date and time in convenient form.

sysdate

returns the system date in the form yymmdd.

Calling sequence:

```
ldate = sysdate(date_array);
```

Arguments:

- a short[3] array, or a **NULL** pointer.

CAUTION: Unless the argument is zero (the defined constant **NULL),** sysdate treats it as a pointer and writes data to the first six bytes it points to. If the argument is not in fact a pointer, the user program could crash or have unpredictable results.

Returned values:

- ldate, a long integer: the system date in year-month-day format, such as 900612.

  If the array argument is provided, this routine puts the year (modulo 1900), month, and day in the three cells of the array. You could then display the date in any desired format by coding such as this:

```
char *month[12] = { “January”, ..., “December” };
short date[3];
long ldate;
       . . .

ldate = sysdate(date);
printf(“%d = %s %d, %d”, ldate,
       month[date[1]], date[2], 1900+date[0]);
```

systime

returns the system time in the form hhmmssss. Although the system returns the time in hundredths of seconds and **systime** passes along the information, the actual accuracy is only about 1/18 of a second, 55 ms.

Calling sequence:

```
ltime = systime(time_array);
```

Arguments:

- either a character[4] array, or the constant pointer **NULL.**

CAUTION: If the argument is not zero (the defined constant **NULL), systime** treats it as a pointer and writes data to the first eight bytes it points to. If the argument is not in fact a pointer, the user program could crash or have unpredictable results.

Returned values:

- ltime, a long integer: the system time including hundredths of seconds; e.g. 14402232 would be the function value at 2:40:22.32 p.m.
- If the array is provided, this routine fills the four cells with the current hour, minute, second, and hundredths of seconds according to the system clock. You can easily use this information to calculate the number of seconds since midnight:

```
short time[4];
double bclk;
        . . .
systime(time);
bclk = 3600*time[0] + 60*time[1] + time[2] + .01*time[3];
```

The hundredths of seconds are accurate to only ±6 (55 ms), so you may prefer to deal in whole seconds:

```
short time[4];
long clk;
        . . .
systime(time);
clk = 3600*time[0] + 60*time[1] + time[2];
```

sysstamp

creates a date and time stamp in printable form.

Calling sequence:

```
sptr = sysstamp( );
```

Arguments:

- none.

Returned values:

- a character pointer, whose object is a 24-character string (23 plus the terminating zero byte) containing the year in yy/mm/dd form, a space, the word at followed by another space, and the time in hh:mm:ss form, and a zero byte.

Example:

```
printf("%s\n", sysstamp( ));
```

would produce output in this form:

```
90/01/05 at  9:15:21.30
```

Command Translation

xlat_cmd

Translate the command byte. This function converts a command byte value to English.

Calling sequence:

```
explan = xlat_cmd(command);
```

Arguments:

- *command*, an integer containing a command.

Returned values:

- a character pointer whose object is a string suitable for printing.

Chapter 10

User Diagnostic Program

Chapter Objectives

This chapter explains how to use the diagnostic program **u_d1,** which is included on your program disk. After reading this chapter, you should be able to use the diagnostic program to:

- check your I/O configuration
- monitor desired specific inputs
- force specific outputs on or off as desired
- perform block transfers to and from intelligent I/O modules
- issue any of the scanner management requests

Prerequisites

You can run the diagnostic program without any knowledge of programming. You do need to know how to start a program under DOS.

You must have the scanner board installed as explained in chapter 3, "Installation." You can run the diagnostic program whether or not a cable is attached to the scanner.

The program normally writes all its output to the screen. If you have a printer attached and want a printed record, press the `Ctrl-PrtSc` combination to toggle printout on and off.

If you use full-screen discrete I/O, the host computer must be configured with the DOS standard **ANSI.SYS** driver, as described in your DOS manual. (The diagnostic program assumes that this has been done and does not check for it.)

Starting the Program

If your switch settings on the scanner board are as set at the factory, you can start the diagnostic program by simply entering its name at the DOS prompt:

```
u_d1
```

User-set switches

If you have changed the settings of switches, you need to tell the program where in memory it will find the scanner board. To do that, use the `/a` option with the memory address (in hex), like this:

```
u_d1 /aD800
```

A chart in chapter 3, "Installation," shows how switch settings on the scanner board correspond to memory addresses in the host computer.

Other options

The **u_d1** program normally assumes that your I/O devices are set at 57.6 Kbaud, that you want the line termination resistor connected, IRQ3 is selected, and that a 1s timeout for management requests is adequate. You can change these assumptions either at program startup by specifying options on the command line, or later while the the program is running. A space or tab must precede every option, including the `/a` option. We give the options in lower case here, but upper case works too.

The following options are defined:

/b	specifies baud rate. Follow the b immediately (no spaces or tabs) with a 1 for 57.6 baud or a 2 for 115.2 baud. /b1 is the default.
/n	specifies the interrupt request line. Follow the n immediately with 3 for IRQ3, 5 for IRQ5, 10 for IRQ10 or 12 for IRQ12. /n3 is the default.
/r	specifies the line termination resistor. Follow the r immediately with a 1 for connected or a 0 for not connected. /r1 is the default.
/t	sets the initial timeout for management requests. Follow the t immediately with a decimal number of 55 milliseconds. The default is /t18 units, about a second.

Example: `"u_d1 /b2"` starts the program with initial operation at 115.2 Kbaud.

CAUTION: If you are running **U_D1,** screen dumps (**[shift]-PrtSc**) cause the scanner to lose communication with the host computer. The screen dump successfully occur but further attempts to operate the system in the message: SCANNER COMMUNICATIONS LOST. Adapters on the I/O link go to Last State or Reset, depending on their switch settings. Re-enter **U-D1 [ret]** to restart the system.

Program Operation

The program tries to establish communication with the scanner. If that attemp succeeds, and a /b or /r option was specified, the program executes a setup command to change the baud rate or resistor setting as specified. The program then does an autoconfigure.

If communication is established, the program displays the message

```
initial sync OK
```

followed by a list of adapters connected.

If the program can't establish communication with the scanner, or if any of the other initialization actions fail, the program displays information about the nature of the failure and then the message

```
Abnormal program termination
```

Main command prompt

The program displays the current operating status and prompts you for a command, like this:

```
operating mode(s): program
your command (H for help):
```

Enter a command from the list later in this section. The program executes the command, displays the results, and then repeats the command prompt.

If you select a command that is incompatible with the current operating mode, the program tells you so and asks you whether it should change the mode as necessary and then execute the command.

If you see this message:

```
scanner communication lost! (code)
```

it means that the host and the scanner are no longer communicating. Either the host watchdog kicked in (if the code is 101) or a scanner problem has occurred. If the code is 101 and you have a printer attached with `Ctrl-PrtSc` in effect, your system is not powerful enough to service the printer and the scanner at the same time. Exit the program, press `Ctrl-PrtSc` to turn off the printer, and you should be able to run the program successfully.

If you receive error code 102, the scanner never successfully initialized with the host. Check your switches on the scanner to make sure they correspond to the memory address given when u_d1 was started

But if you receive the message with any code other than 101 or 102, please write down the code and call Allen-Bradley Technical Service.

Command summary

Here is a quick list of commands. If you are running the diagnostic program and don't have this manual with you, you can see this summary on screen by typing H at the command prompt.

(You can also examine a single I/O group from the main command prompt and have an opportunity to force outputs. To do this, see "Single-Group Discrete I/O" below.)

Type:	Command:	Description:
Discrete I/O	C	clear (reset) all discrete outputs
	D	full-screen discrete I/O
Management Requests	A	autoconfigure
	F	fault dependent group
	L	link status
	M	set operating mode
	SE	setup (baud rate and resistor)
	SC	scan list
	T	change timeout
Block Transfer	BTR	read from intelligent I/O module
	BTW	write to intelligent I/O module
	BTC	continuous block transfers to or from a module
	BTM	multiple block transfers to and/or from multiple modules
Other	G	display global variables
	Q	quit the program
	X	exit the program (same as quit)

These commands (except the last group) are fully explained in the sections that follow.

Single-Group Discrete I/O

View I/O Group
If you answer the command prompt not with a command but with a rack and group number (each 0 to 7, with no separators), the program displays, in hex, the current contents of the input and output image tables for that rack and group. (The high byte, slot 1 within the group or terminals 17-10 on a double-density module, shows as the two digits at the left.)

Set Outputs
To leave the output value unchanged, just press the `Enter` key. But to change the output value, you have several choices:

- Type 1-4 hex digits to be written to the output image table. If there are two single density modules in the group, enter the two digit value for slot 1 followed immediately by the two digit value for slot 0.
- Type `HI` or `LO` to display, in hex, the indicated byte from the input and output image tables. The program prompts you for new output, also in hex. If the group contains two single density modules, `HI` corresponds to slot 1 and `LO` to slot 0.
- Type `BIT` to access one particular input or output terminal. You can specify the terminal number (octal 0-17, 17 being the high-order bit) adjacent to the word `BIT` or the program prompts you. The program then displays the corresponding input and output image bits and prompt you for a new output bit. Enter `1` to set the output terminal on or `0` to reset.

Full-Screen Discrete I/O

From the main command prompt, the `D` command makes the program display the complete output and input image tables on screen. You can exit full-screen mode and return to the command prompt by pressing the `Esc` key at any time.

Display Format

The input and output image tables are shown as words of four hex digits, organized by rack and group. (You can use the F9 key, as explained below, to convert the display to binary.) Within each word, the four digits correspond to terminals 17-14, 13-10, 07- 04, 03-00 from left to right. This means that slot 0 (the left slot) is at the right, and slot 1 is at the left.

In full-screen mode, the program continuously monitors all discrete inputs and updates the screen display whenever any inputs change. This lets you test all input modules and verify immediately on the screen whether a correct input was received by the scanner.

One output group is always highlighted, and you can control which one is highlighted by using the cursor keys: the four arrows plus Home, PgUp, PgDn, and End. The highlighted group is also called the "current group."

WARNING: Should an adapter fault while you are in full-screen mode, the inputs from that module remain in their last known valid state. You are not notified of the fault until you leave full-screen mode.

Setting Outputs

You can also set the outputs in any module group. To do this, use the cursor keys to move the highlight block to the desired I/O group. You can then enter the desired output value, in hex (two digits for high byte followed immediately by two digits for low) and press the Enter key.

Note: Characters above F will set outputs but these characters have no meaning in hex.

If you make a mistake, use the backspace key to erase the wrong digits and type the right ones before pressing Enter. The program then writes the new output value to the image table. (If you press any cursor or function keys before pressing Enter, the output group value is not changed.)

Function keys

Several function keys are active while you're in full-screen mode:

Function Key:	Description:
F1	turns on "echo mode". In echo mode, all inputs are copied to the corresponding outputs. By attaching I/O Simulator Modules (cat. no. 1771-SIM), which have both input toggle switches and output indicator lights, you can verify by eye that inputs and outputs are properly addressed. "Echo mode" overwrites any output value you enter into an output location. If "echo mode" is on and you set an output, it is immediately changed to reflect the state of the corresponding input. However, if an output has been set to count, it continues to count regardless of the state of "echo mode."
F2	turns off echo mode.
F3	starts a background count in the currently highlighted output group, beginning with the current value. (To start counting from zero, press the three keys `0`, `Enter`, and `F3` in succession.) The background count overrides echo mode for this group, and continues in this group even after you move the highlight block to another group. You can start multiple groups all counting in background by successively moving the highlight block to each and pressing `F3`. If you change an output value while that group is engaged in background count, the count continues from the new value.
F4	turns off the background count in the currently highlighted group. If echo mode (F1 key) is selected, the current input is copied to output immediately.
F9	displays the values of the currently highlighted I/O group in binary. The binary display is static, and is not updated by entry of an output value, by changed input, by echo mode, or by background count; but you can re-press F9 to display current values in binary. (If you enter a new output value, it must still be in hex.) The binary display disappears when you press Enter, a cursor key, or a function key.
F10	clears the output image table, turns echo mode off, and turns off all background counts.

Management Requests

For all management requests, the program prompts you for any necessary data, queues the request, waits for a confirmation from the scanner (or until the program decides the request has timed out), and displays the results. The requests are listed in the remainder of this section.

Set operating mode

`M` command: The program prompts you for Program, Run, or Test mode.

Link status

`L` command: no data required.

Autoconfigure

A command: no data required.

Setup

SE command: The program prompts for a one-digit baud rate multiplier (1 and 2 are valid), then for a one-digit resistor value (1 to connect the line termination resistor and 0 to disconnect). Just pressing the Enter key in response to either of the first two prompts leaves the previous value unchanged.

There is a third prompt, for debugging mode: a 1 disables the scanner's watchdog and any other value (including just the Enter key) re-enables it.

Scan list

SC command: The program prompts for the length of the scan list and then the scan list itself. You enter each adapter in the scan list as a one-digit rack number (0–7) followed immediately by a one-digit starting group number (0, 2, 4, or 6).

You may need to make several identical responses in a row. You can compress this repetitive input by using a repeat count with an asterisk. For instance, 3*14 would enter the adapter at rack 1, group 4, in the next 3 positions in the scan list.

link statulFault dependent group

F command: The program asks you for the rack and starting group number of each adapter in the current scan list. You reply with the fault dependent group number (0 to 7, or N for no group).

As with the scan list command, you may need to make repetitive responses. Again, use a repeat count with an asterisk. For instance, 6*N is equivalent to making the N response 6 times, leaving the next 6 adapters out of any fault group.

Timeout

T command: Unlike the other commands in this section, the T command doesn't cause a request to be issued to the scanner. Instead, this command sets the diagnostic program's own timeout interval for management requests. The program asks you:

```
MR timeout in 55-msec units:
```

Enter a decimal number. (A second is about 18.2 units; scan-list requests, which are the slowest, can take up to 12 units.)

If the scanner doesn't complete a given request (or respond to an interrupt from the host) in the time interval you specified, the host abandons the operation and reports an error on your screen.

When the diagnostic program began executing, the timeout interval was automatically set to 18 units, unless you used the /t option on the command line.

Block Transfers

You perform block transfers from the main command prompt by typing BT. The program then asks you for a letter R or W for a single BT, M for multiple BTs, or C for continuous BTs.

You can bypass the second prompt by specifying the subcommand on the same line as the BT; for example, BTR.)

Single block transfers

For a single BT read or write, the program asks for the module slot address:

```
rack, group, slot as three octal digits:
```

For example, enter 421 for rack 4, group 2, high slot. The program also wants to know how many words of data to transfer:

```
data length in words:
```

If you change your mind about doing the block transfer, simply answer either of the above prompts with an X.

For a BT write, the program also prompts for the data, one word at a time, beginning like this:

```
data word 00/00(hex) (enter in hex, X to cancel):
```

Notice how the program gives you the word number in both decimal and hex. (Data words are numbered starting at zero and ending at one less than the word count you entered.) Your input should be one to four hex digits followed by the `Enter` key. Repeated values can be entered using the asterisk; for instance, `10*8A32` indicates 10 (not 16: repeat counts are in decimal) consecutive words of 8A32h. After you've entered the BT information, the program queues the BT, waits for it to finish, and displays the results.

Multiple block transfers

You can use this feature to execute multiple block transfers at computer speeds rather than human speeds. The program gets all information about all the BTs from you; then it queues them all to the scanner in quick succession. You can mix read and write BTs, and they can be to different modules or the same module. The program asks you:

```
how many BT (up to 65):
```

Note: If you answer with a number greater than 42, you may overflow the scanner's queue and cause it to refuse some of the block transfers.

For each BT, the program asks you:

```
BT #12: Read/Write/X (or " to repeat previous):
```

If you answer with an R or a W, the program prompts you for the details of this block transfer, using the same questions as under "Single Block Transfers" above. An X tells the program that you've changed your mind and don't want any of the block transfers to be queued. A ditto mark (") means that all the details of this block transfer should be exactly like the previous one. If you have several identical block transfers, you can use a repeat count. For instance, 5*" means that this BT and the next four should be exactly like the preceding one.

As soon as you've entered the data for the last BT, the program queues them all up to the scanner. Then the program gives a running count of the number completed until all have been finished. At this point the program summarizes how many, and which ones, finished successfully or unsuccessfully and gives you a chance to display details:

```
number of BT to display (X to stop):
```

Enter a BT number (1 up to the total number of BTs). The program displays the details of that BT, including its confirmation status, and repeats the prompt. At any time you can answer the above prompt with a `0` (zero) if you want to re-display the completion summary. When you've seen all the details you want, enter an X to return to the main command prompt. Finally, the program lets the operator enter numbers repetitively to view the details of the indicated BTs.

You must repeat the multiple block transfer steps **each time** new information is required. Repeated requests of a specific block transfer module will show the same data.

Continuous block transfers

The `c` subcommand of the `BT` command asks you for details of a BT read or write (see "Single block transfers" above) and executes that BT again and again until you press any keyboard key. The reason is displayed for each BT that fails; otherwise the only display is the number of BTs executed.

Chapter 11

Troubleshooting

Chapter Objectives

This chapter gives you an introduction to diagnosing and resolving any problems you may have in operating an application involving the IBM PC I/O Scanner. After reading this chapter you should be able to:

- check the installation of the scanner and correct it if necessary
- check your program for likely errors and correct them
- check and correct the connections of your 1771 Series I/O modules and adapters
- determine whether any remaining problems are most likely in your software, in the scanner, or in the attached adapters and modules.

You should also have the manuals for your 1771 Series I/O products handy.

A troubleshooting chart for the 6008–SI module is presented on the pages that follow.

Troubleshooting the I/O Scanner

Problem:	Possible Solution:
Scanner does not communicate with the IBM **U_D1** diagnostic program does not run	Check dip switches 7–10 on the scanner board. If IBM–XT, these switches should be open. If IBM–AT or T–50, these switches should be closed. (open = 1, closed = 0)
	Check that dip switches 1–6 correspond to the address supplied in the **setup_6008()** library routine or the **/a** option of the **U_D1** program (open = 1, closed = 0)
	Check memory map to insure a clear 6k + 1 memory window
	Last resort. Set dip switches 1–6 to an open area of user RAM, or remove some user RAM to create an open area. Install 6008–SI there.

Problem:	**Possible Solution:**
Scanner is in sync with the IBM, but there is no communication with the I/O racks	Check status of LED's at the ASB remote adapters: Red Light ON indicates a Rack Fault Green Light ON indicates normal operation in RUN mode. Green Light BLINKING indicates normal operation in PROGRAM or TEST mode.
	Check baud rate at the ASB and the **setup_6008()** routine.
	Perform an AUTOCONFIGURE management request from either your program, or the **U_D1** diagnostic program. Determine whether the adapter numbers returned by the **cfg_info()** routine corresponds to those of the remote adapters. Use this formula to determine adapter number: Adapter # = 4 * rack + starting group / 2
	Check remote I/O cable is made correctly and securely at both sides: C S B (clear, shield, blue) 15–pin D–shell 6 7 8 swing arm 3 2 1
	Check power at the remote I/O rack.
	Make sure that the **host_active()** routine is disabled during testing, or is being called frequently enough to ensure the host watchdog does not time out.

Problem:	**Possible Solution:**
Scanner does not communicate with the IBM/ U_D1 diagnostic program does not run.	Check specified interrupt vector. The vector must match the hardware jumper setting discussed in chapter 3.

Problem:	**Possible Solution:**
Discrete I/O is updating, but block transfers are not	Make sure you are addressing the proper module by using this formula: Module address = rack * 16 + slot #
	Check the your program to make sure that the code for block transfer to that module exactly follows the examples in chapter 8.
	Make sure that block transfer length is specified in the block transfer (**QBT**) data packet.
	Use the **U_D1** program to try block transfers. If they execute properly, the fault is most likely your program.
Block transfers are working erratically	Declare the **QBT** data packet as “static”. Use a different data packet for each block transfer.
Adapter “READY” lights blink briefly, then go out	Make sure your program is using the **host_active** macro as described in chapter 5, ”Host Watchdog”.

Appendix A

Header Definitions

DEFINITIONS FOR THE IBM PC I/O SCANNER, 6008–SI

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```
/**************    general operating status bits    **************/

#define SO_PROGRAM  0x01

#define SO_TEST     0x02

#define SO_RUN      0x04

#define SO_DEBUG    0x08

#define SO_OIT_ERR  0x10

#define SO_BT_PEND  0x20

#define SO_FAULT    0x40

#define SO_CHG_FLT  0x80
```

```
/**************    confirmation status values    **************/

#define SC_PENDING      0xFF

#define SC_OK           0x00

#define SC_NOT_OK       0x01

#define SC_BAD_REQ      0x10

#define SC_BAD_PARAM    0x11

#define SC_REQ_PEND     0x12

#define SC_PROG_MODE    0x13

#define SC_BTQ_FULL     0x14

#define SC_BAD_LEN      0x15

#define SC_BAD_CONFIG   0x16

#define SC_BT_TIME      0x23

#define SC_BT_DIR       0x26

#define SC_BT_LEN       0x27

#define SC_BT_CHKSUM    0x28

#define SC_BAD_VERSN    0xFE


/**************    operating mode data values    **************/

#define CM_PROGRAM  0x01

#define CM_TEST     0x02

#define CM_RUN      0x04
```

```
/**************   command specifier codes    **************/

#define C_BT_READ  0x01

#define C_BT_WRITE 0x02

#define C_AUTOCONF 0x10

#define C_SCANLIST 0x11

#define C_FLT_GRP  0x12

#define C_SETUP    0x13

#define C_SETMODE  0x20

#define C_LINKSTAT 0x21


/**************   device information    **************/

#define SL_SIZE     0x03

#define SL_KNOWN    0x04

#define SL_EXISTS   0x08

#define SL_IN_SCAN  0x10

#define SL_SNGL_PT  0x20

#define SL_NODE     0x40

#define SL_FAST_NA  0x80

#define SF_GRP_NUM  0x07

#define SF_IN_FGRP  0x08

#define SF_ON_LINE  0x70

#define SF_GRP_FLT  0x80
```

```
/**************    symbolic constants   **************/
#define Bool int              /* documents truth-value variables */
#define OK     ((Bool)0)
#define NOT_OK ((Bool)1)
#define IN  1                 /* input or output image table */
#define OUT 0
#define HI  1                /* high or low byte in discrete funcs */
#define LO  0
#define MAXGROUP 64              /* max # of module groups */
#define MAXMOD   (MAXGROUP*2)    /* max # of attached modules */
#define MAXADAPT 32              /* max # of adapter addresses */

/************  type definitions for user queue packets  ************/
#define MAXMRDAT 128           /* # of data bytes used by mgmt req */
typedef struct {               /* QMR: management req queue packet */
       unsigned qmr_id;               /* ID # of packet */
       unsigned qmr_stat;             /* confirmation status */
       unsigned qmr_len;              /* length of data (in bytes) */
       char     qmr_data[MAXMRDAT];   /* data area */
       } QMR;
#define MAXBTDAT 64            /* # of data words used by BT req */
typedef struct {               /* QBT: block transfer queue packet */
       unsigned qbt_id;               /* ID # of packet */
       unsigned qbt_stat;             /* confirmation status */
       unsigned qbt_len;              /* length of data (in words) */
       unsigned qbt_data[MAXBTDAT];      /* data area */
       } QBT;
```

Symbols

#include, 4-7
/a option, 11-1
/d option, 4-11
_q, 4-12

Numbers

1771 Remote I/O protocol, 2-1

A

accessing
  by byte, 6-3
  single input terminal, 6-2
address, RAM, 3-4
AND, 6-2, 6-3
ANSI.SYS, 10-1
audience, 1-1
auto, 4-11
autoconfigure, 7-9, 7-15, 10-8

B

block transfer, 8-1
  continuous, 10-11
  display results, 8-12
  emtpy scanner queue, 8-6
  multiple, 10-10
  queueing, 8-4
  single, 10-9
  to a 1771-DCM, 8-17
  to a PLC5 processor, 8-15
  unsolicited, 8-13
block transfers, 10-9
BOOL typedef (boolean), 4-9
Borland
  C++, 4-11
  TLINK linker, 4-11
  Turbo C++, 4-11
BT. *See* block transfer
bt_done, 8-10
bt_print, 8-12
bt_que, 8-5
bt_read, 8-6
bt_write, 8-6

C

C_, 4-11
C_AUTOCONF, 7-9
C_BT_READ, 8-12
C_BT_WRITE, 8-12
C_FLT_GRP, 7-14
C_LINKSTAT, 7-11
C_SCANLIST, 7-12
C_SETMODE, 7-6
C_SETUP, 7-7
cable, attaching I/O, 3-7
calculations, subscript, 6-2, 7-14
cfg_info, 7-16
clrbit, 6-8
CM_, 4-11
CM_PROGRAM, 7-6
CM_RUN, 7-6
CM_TEST, 7-6
codes, confirmation status, 7-19
COM2, 3-2
command translation, 9-5
compiling
  Borland C++ 2.0, 4-12
  Borland Turbo C++ 1.0, 4-13
  Microsoft C 5.1 or 6.0, 4-14
configuration information bit fields, 7-17
confirmation status codes, 7-19, 8-11
constants, defined, 4-9
constants, prefixes
  C_, 4-11
  CM_, 4-11
  MAX, 4-11
  SC_, 4-11
  SF_, 4-11
  SL_, 4-11
  SO_, 4-11
continuous block transfer, 10-11
conventions, 1-2
Ctrl-Alt-Del, 2-10
Ctrl-PrtSc, 10-1

D

data structure, 7-2, 8-2
Date/time stamp, 9-3
debugging mode, 7-7
defined constants, 4-9
diagnostic program, 10-1
  command summary, 10-4
direct image table, 6-1
discrete I/O, 2-3, 6-10
  full-screen, 10-1
  full–screen, 10-5
  single group, 10-5
discrete transfer, 8-14
diskette, contents, 4-1
display results, 7-20, 8-12

E

executing, management requests, 7-3
extern, 4-11

F

F command, 10-8
fatal_6008, 5-1
Fatal_6008( ), 5-7, 5-11
fault dependent group, 7-13, 10-8
fault information byte, 7-17
Fault/fault dependent, 7-3, 10-4
FDG. *See* fault dependent group
files
  diagnostic program, 4-2
  header, 4-7
filrec, 6-10
flt_info, 7-17
fopen, 6-10
force outputs, 10-4
full-screen discrete I/O, 10-1
full–screen discrete I/O, 10-5
function keys, 10-7

G

g_, 4-12
G_accum, 9-2
G_act_host, 5-6
g_act_scnr, 4-8, 5-1
G_decrem, 9-2
g_decrem, 7-3
g_ipt, 6-1
g_oit, 6-1
G_op_stat, 5-7
g_op_stat, 7-6, 7-7
g_pkt_err, 7-2
g_timeout, 7-1, 7-3
g_ver_host, 5-2
g_ver_scnr, 5-2
getbit, 6-4
getbyte, 6-5
getword, 6-5
global RAM, 2-6, 2-7
global variables, 4-12
glossary, 2-3

H

H_6008SI.H, 4-7, 4-11
hardware interrupt
  IRQ10, 3-1
  IRQ12, 3-1
  IRQ3, 3-1
  IRQ5, 3-1
hardware, required, 1-1
header definitions, A-1
header files, 4-7, 4-9
HI, 6-5
host computer, 2-1
Host Watchdog, 5-6
host watchdog, 2-10
Host_active, 5-6
host_active, 4-7, 4-8, 5-1
Host_active( ), 4-8

I

I/O addressing, 2-5
I/O cable, attaching, 3-7
I/O chassis, 2-2
I/O modules, 2-2
I/O ports, 3-4
if tests, 7-5
IN, 6-4
init, 4-10

installation procedure, 3-5
intelligent I/O, 2-3
interrupt
  hardware, 3-1
  software, 3-3
io_, 4-11
IRQ10, 3-1
IRQ12, 3-1
IRQ3, 3-1
IRQ5, 3-1

J

jumpers, interrupt request line, 3-2

L

L command, 10-7
library routines, 6-4
Link Status, 10-4
link status, 7-10, 7-15, 10-7
linking
  Borland C++ 2.0, 4-12
  Borland Turbo C++ 1.0, 4-13
  Microsoft C 5.1 or 6.0, 4-14
LO, 6-5

M

M command, 10-7
main, 4-10
main program, 4-10
management request, 7-3
Management Requests, 10-4
management requests, 10-7
  formatting, 7-20
MAX, 4-11
MAXADAPT, 4-9
MAXGROUP, 4-9
MAXMOD, 4-9
MCB. *See* module control byte
memory address switches, 10-2
memset, 7-13
modes, operating, 2-7
module control byte, 8-13
MR. *See* management request
mr_print, 7-4, 7-21
mr_wait, 7-1, 7-5
multiple block transfers, 10-10

N

names
  global variables, 4-12
  link times, 4-11
names, avoiding conflict, 4-10
NOT_OK, 4-9, 8-5
Null pointer, 9-3

O

OK, 4-9, 8-5
operating mode, set, 10-7
operating modes, 2-7
options (Bool type functions), 4-10
ORed, 6-4, 7-14
OUT, 6-4

P

packet check, 8-9
packets, misusing, 8-3
partial refresh, 6-11
pick, 4-10
polling for completion, 8-8
ports
  COM1, 3-2
  COM2, 3-2
  I/O, 3-4
Ports, COM2, 3-2
pr_array, 4-10, 6-9
pr_globl, 4-10
print results, 7-20, 8-12
printer display image table, 6-9
procedures
  change interrupt request line setting, 3-2
  installing scanner, 3-5
program skeleton, 4-7
programs, writing your own, 4-7
putbit, 6-6
putbyte, 6-8
putword, 6-9

Q

QBT, 8-2
qbt_data, 8-3
qbt_len, 8-2
qbt_stat, 8-2
QMR, 7-2
QMR packet, 5-3
QMR pkt, 5-3
qmr_data, 7-2, 7-15
qmr_len, 7-2, 7-15
qmr_stat, 7-2, 7-5
qmr_stat field, 5-3
queueing block transfer, 8-4

R

RAM address, 3-4
RAM, global, 2-6, 2-7
register, 4-11
related publications, 1-1
relationship to 1771–I/O, 2-1
requests, management, 10-7

S

sample program, 4-9
SC command, 10-8
SC_, 4-11
SC_BAD_CONFIG, 7-20
SC_BAD_LEN, 7-20
SC_BAD_PARAM, 7-20, 8-11
SC_BAD_REQ, 5-5, 7-20, 8-11
SC_BAD_VERSN, 5-5
SC_BT_CHKSUM, 8-11
SC_BT_DIR, 8-11
SC_BT_TIME, 8-11
SC_BTQ_FULL, 8-11
SC_BTQ_LEN, 8-11
SC_NOT_OK, 5-5, 8-11
SC_OK, 5-4, 5-5, 7-20, 8-11
SC_PENDING, 5-5, 7-2, 7-20, 8-11
SC_PROG_MODE, 7-20
SC_REQ_PEND, 7-20
Scan List, 10-4
scan list, 7-11, 10-8
scanner commands, 2-9
Scanner Status, 5-7
scanner watchdog, 2-10
scans, number of, 8-7
SE command, 10-8
set operating mode, 7-6, 10-7
setbit, 6-7
settings
  interrupt request line, 3-2
  memory address, 3-6
  switch, 3-5
Setup, 10-4
setup, 7-7
setup command, 10-3, 10-8
setup_6008, 4-7, 4-10, 5-1, 5-2
SF_, 4-11
SF_GRP_FLT, 7-18
SF_GRP_NUM, 7-18
SF_IN_FGRP, 7-18
SF_ON_LINE, 7-18
single block transfers, 10-9
single group discrete I/O, 10-5
single terminal, 6-2
SL_, 4-11
SL_EXISTS, 7-17
SL_FAST_NA, 7-17
SL_IN_SCAN, 7-17
SL_KNOWN, 7-17
SL_NODE, 7-17
SL_SIZE, 7-17
SL_SNGL_PT, 7-17
SO_, 4-11
SO_BT_PEND, 5-8
SO_CHG_FLT, 5-8
SO_DEBUG, 5-8, 7-7
SO_FAULT, 5-7, 5-8
SO_OIT–ERR, 5-8
SO_OIT_ERR, 5-8, 8-13
SO_PROGRAM, 5-8
SO_RUN, 5-8
SO_TEST, 5-8
software interrupt, 3-3
software, required, 1-2
source code, 1-2

start-up, 5-2
start_6008, 4-7, 4-10, 5-1, 5-5
starting diagnostics, 10-2
static, 4-11, 8-3
stderr, 6-9
STDIO.H, 4-7
stdout, 6-9, 8-12
stop_6008, 4-10, 5-1
Stop_6008( ), 5-12
subscript calculation, 6-2, 7-14
switches
  factory set, 10-2
  memory address, 10-2
  settings, 3-5
  user-set, 10-2
sysdate, 4-10
Sysdate( ), 9-3
sysstamp, 4-10, 9-5
systime, 4-10

T

terms, 2-3
time to completion, 8-6
Time-out, management request, 10-2
timeout, 7-3
timeout command, 10-9
Timeout, T, 10-4
timing formula, 8-7
Timing Loops, 9-1
TLINK linker, 4-11
troubleshooting, 11-1

U

u_d1, 10-1
  options, 10-2
U_D1.C, 4-9
U_D1.H, 4-9
Unsigned, 5-7, 6-1
unsolicited block transfer, 8-13
update, 6-11

V

variable names
  auto, 4-11
  register, 4-11
  static, 4-11

W

watchdog
  host, 2-10
  scanner, 2-10

X

xlat, 4-8
xlat_cfg, 4-10, 7-20, 7-22
xlat_cmd, 4-10, 9-5
xlat_conf, 4-10, 7-6, 7-19
xlat_flt, 4-10, 7-20
xlat_opst, 4-10
Xlat_opst( ), 5-9

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